Advancing adolescent health promotion in the digital era

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A thesis submitted to fulfil requirements for the degree of

Doctor of Philosophy

Faculty of Medicine and Health

The University of Sydney

2025

STATEMENT OF ORIGINALITY

This is to certify that to the best of my knowledge, the content of this thesis is my own work. This thesis has not been submitted for any degree or other purposes.

I certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged.

Rebecca Raeside 26 September 2024

ABSTRACT

Background: Adolescents (10-24 years old) are calling for high-quality digital services to support their health and wellbeing. With non-communicable diseases on the rise and adolescents at risk due to emerging public health challenges, strategies to improve adolescent health are needed. Digital strategies (e.g. text messages, websites) hold potential as they are low-cost and scalable. This thesis aims to provide evidence to advance adolescent health promotion in the digital era.

Methods: Systematic review with meta-analysis (Ch 2); qualitative study with adolescents (Ch 3); mixed-methods co-design of Health4Me digital health intervention (DHI) with adolescents (Ch 4); RCT protocol (n=390) of Health4Me versus control over 6-months (Ch 5); Evaluation of digital recruitment strategies for virtual clinical trials, using Health4Me as case study (Ch 6); qualitative study with stakeholders (Ch 7).

Results: DHIs have potential to improve adolescent health and wellbeing due to shared protective factors e.g. good nutrition, physical activity (Ch 2), and adolescents desire appealing, credible, relevant and actionable information through digital platforms (Ch 3). The co-design process supported these findings resulting in the Health4Me intervention, which is useful, acceptable and engaging to adolescents (Ch 4). A virtual clinical trial to determine the effectiveness of Health4Me to improve adolescent nutrition and physical activity is underway (Ch 5). Digital recruitment strategies (e.g. social media) were low-cost and effective, with potential to increase trial participation (Ch 6). Stakeholders supported adolescent DHIs yet had design and equity considerations to be met for successful implementation (Ch 7).

Conclusion: This thesis provides evidence to support implementation of DHIs to improve adolescent health and wellbeing through shared protective factors. Future research will define priorities for intervention optimisation and an implementation trial with long-term follow-up.

ACKNOWLEDGEMENTS

In these acknowledgements, I aim to pay gratitude to everyone who helped me get through all the research and writing of this thesis – from my amazing supervisors, colleagues, family, and friends. Yet, words hardly seem enough to express how much each and every person has helped me through this journey.

Firstly, to you Steph. I first approached you with this idea for my PhD one afternoon and since then you have been nothing but supportive of me from helping me get started, all the way through to the finish line. You are so generous with not only your time and expertise, but also through the opportunities that you have provided. Your style of supervising has allowed me to become my own researcher. Through your guidance, I can now develop my own research ideas and see them through, supervise other students, teach other students, conduct research that has integrity, involve myself in committees, present confidently at conferences and the list just goes on. I have also had the pleasure of being one of your students through some of your biggest career wins – A Eureka Prize for Emerging Leader in Science, a Young Tall Poppy Award, MRFF Grants (x2) and your Sydney Horizon Fellowship. You are not only an amazing supervisor to Ally, Sisi and I, but also an inspiring leader to others around you. I am so privileged to have had you to lead me on this journey – thank you.

Secondly, to Julie. My secondary supervisor and the first person who hired me as a research assistant and saw my potential back in 2018. Over the past 6 years, you have provided me with guidance and confidence to be the researcher I am today. Your ability to look forward and see the bigger picture is something I truly admire about you. You helped me develop my skills and track record to not only complete a PhD, but to become an independent

researcher. You have provided the most amazing example of what a research team should be. Through WARC, to ECHO, then SOLVE (what a journey we all went on!), and now, your new home up at Bond. I hope they all know just how lucky they are to have an amazing leader.

Next, I would like to pay a special thanks to the Youth Wellbeing Team – Ally, Sisi and Sara. Allyson Todd, thank you for being along for this crazy PhD ride with me – I could not have done it without you! Together we recruited 390 adolescents in 12 months (it all seems like a blur now). Now, I get to see where your PhD journey takes you, and I know you're going to be amazing. Sisi Jia –I'm so thrilled we have been on this journey together and you are nearly at the finish line too! It's always been great to have someone at the same stage who understands all the ups and downs that go with doing a PhD. And Sara Wardak, I have seen you go from a high school student to uni student who is excelling at every turn. You are one amazing young person, and I can't wait to see where your journey takes you. Finally, to all the amazing HAPYUS members who have helped me with the Health4Me RCT over the years. This project wouldn't have happened without you. I am eternally grateful that you came on board to share your voices, thoughts and opinions, and that I got to listen to you all.

The amount of people I must thank shows just how much transformation our team has gone through over the years. Both the ECHO and SOLVE teams have played such an important role throughout my PhD. I have been lucky enough to work closely with so many of you, and be inspired by all your friendship, advice and support. A special thank you to Dr Anna Singleton – I was first your research assistant when you did your PhD, now I'm about to finish mine! You are an incredible friend and mentor.

To my Family (Dad, Mum, Jes, Mitch and James) – thank you for being my biggest cheerleaders. I don't know how I'll ever repay the love and support you have shown me over the last three and a half years. Thank you for celebrating the wins with me and bringing me back to earth when things didn't go my way. I hope I have made you proud and I love you all so much!

To Michael, the universe allowed us to meet at just the right time (nearly halfway through this PhD journey). You are the calm and level-headed to my crazy. You always assure me that everything will work out, even when I'm being irrational and telling you it won't. You've seen all the emotions I've gone through and still been my absolute rock. You are so patient, loving and supportive and I wouldn't have been able to do this without you. I love you.

To myself – you did it! You are incredible, strong and resilient. This journey has taught me more about myself than I ever knew before. I purposely saved this to be the last thing I wrote in my thesis because by writing this, I realise that it is the people and the passion which really got me through.

Finally, a special thank you to my funders. Firstly, the Australian Government Medical Research Futures Fund for the grant to conduct my PhD research. Secondly, to The University of Sydney, The Cardiac Society of Australia and New Zealand and SOLVE-CHD for providing scholarships throughout my PhD research.

The Introduction (Part One) and Discussion of this Thesis have been proofread for grammatical errors, referencing errors and clarity. This was conducted by Dr Teresa Goudie from Good Prose Studios.

DEDICATION

I dedicate this thesis to my amazing parents. Mum and Dad - thank you for instilling within me a lifelong love of learning. It is that passion which got me through the hardest of days of the last three and a half years. I love you.

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LIST OF ABBREVIATED TERMS AND ACRONYMS

ANCOVA: Analysis of Covariance

ASR: Adjusted Standardised Residual

ANZCTR: Australia New Zealand Clinical Trials Registry

AUD: Australian Dollar

BMI: Body Mass Index

CALD: Culturally and linguistically diverse

CBT: Cognitive Behavioural Therapy

CDI: Children's Depression Inventory

CES-DC: Center for Epidemiological Studies Depression Scale for Children

CHU9D: Child Health Utility Instrument

CI: Confidence Interval

COREQ: consolidated criteria for reporting qualitative research

COVID-19: Coronavirus disease of 2019

EDE-Q: Eating Disorder Examination Questionnaire

EOI: Expression of Interest

eHEALS: eHealth Literacy Scale

GAD: Generalised Anxiety Disorder

GPs: General Practitioners

GRIPP: Guidance for Reporting Involvement of Patients and the Public

GSE: General Self Efficacy Scale

HADS: Hospital Anxiety and Depression Scale

HAPYUS: Health Advisory Panel for Youth at the University of Sydney

IOI-S: InsideOut Institute Screener

IRSAD: Index of Relative Socioeconomic Advantage and Disadvantage

K6: Kessler Psychological Distress Scale

LMICs: Low- and Middle-Income Countries

MASC: Multidimensional Anxiety Scale

MVPA: Moderate to Vigorous Physical Activity

NCDs: Non-Communicable Diseases

NGO: Non-Government Organisation

PANAS-C: Positive and Negative Affect Schedule Children

PedsQL: Pediatric Quality of Life Inventory

PHQ: Patient Health Questionnaire

PPI: Patient and Public Involvement

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analysis

QOL: Quality of Life

RE-AIM: Reach, Effectiveness, Adoption, Implementation, Maintenance

REDCap: Research Electronic Data Capture

RCT: Randomised Controlled Trial

RoB: Risk of Bias

SE-HEPA: Self Efficacy for Eating and Physical Activity

SCT: Social Cognitive Theory

SD: Standard Deviation

SDT: Self-Determination Theory

SMD: Standardised Mean Difference

SMS: Short Message Service

USD: United States Dollar

USDA: United States Department of Agriculture

WHO: World Health Organisation

PUBLICATIONS AND PRESENTATIONS ARISING FROM THESIS

Peer-reviewed publications

1. [CHAPTER ONE (Part 2) – FIRST AUTHOR] **Raeside R**. Advancing adolescent health promotion in the digital era. *Health Promotion International* 2024; accepted 2nd November 2024.

2. [CHAPTER TWO – FIRST AUTHOR] **Raeside R**, Jia SS, Todd A, Hyun K, Singleton A, Gardner LA, Champion KE, Redfern J, Partridge SR. Are Digital Health Interventions That Target Lifestyle Risk Behaviors Effective for Improving Mental Health and Wellbeing in Adolescents? A Systematic Review with Meta-analyses. *Adolescent Res Rev* 2023; 9:193-226. doi: 10.1007/s40894-023-00224-w

3. [CHAPTER THREE – FIRST AUTHOR] **Raeside R**, Jia SS, Redfern J, Partridge SR. Navigating the Online World of Lifestyle Health Information: Qualitative Study With Adolescents. *JMIR Pediatr Parent* 2022; 5(1):e35165. doi: 10.2196/35165.

4. [CHAPTER FOUR – FIRST AUTHOR] **Raeside R**, Todd A, Wardak S, Gardner L, Champion KE, Kang M, Mihrshahi S, Steinbeck K, Redfern J, Partridge SR, HAPYUS, The Health4Me Team. Striking the right balance: co-designing the Health4Me healthy lifestyle digital health intervention with adolescents. *Research Involvement and Engagement* 2023; 9:114. doi: 10.1186/s40900-023-00524-4

5. [CHAPTER FIVE – FIRST AUTHOR] **Raeside R**, Spielman K, Maguire S, Mihrshahi S, Steinbeck K, Kang M, Laranjo L, Hyun K, Redfern J, Partridge SR, The Health4Me Team. A Healthy Lifestyle Text Message Intervention for Adolescents: Protocol for

the Health4Me Randomized Controlled Trial. *BMC Public Health* 2022; 22:1805. doi: 10.1186/s12889-022-14183-9

6. [CHAPTER SIX – FIRST AUTHOR] **Raeside R**, Todd AR, Barakat S, Rom S, Boulet S, Maguire M, Williams K, Mihrshahi S, Hackett ML, Redfern J, Partridge SR and The Health4Me Team. Recruitment of Adolescents to Virtual Clinical Trials: Recruitment Results From the Health4Me Randomized Controlled Trial. *JMIR Pediatrics and Parenting* 2024;7:e62919. doi: 10.2196/62919

7. [CHAPTER SEVEN – FIRST AUTHOR] **Raeside R**, Todd A, Sim KA, Kang M, Mihrshahi S, Gardner LA, Champion KE, Skinner J, Laranjo L, Steinbeck K, Redfern J and Partridge SR. Accelerating implementation of adolescent digital health prevention programs: analysis of insights from Australian stakeholders. *Front. Public Health* 2024; 12:1389739. doi: 10.3389/fpubh.2024.1389739

Published abstracts

1. [SENIOR AUTHOR] Partridge SR, Todd AR, Redfern J, **Raeside R**. Challenges Recruiting and Screening Adolescents for a Cardiovascular Disease Prevention Intervention: First Results From the TEXTBITES Study. *Heart, Lung Circ* 2024; 33:S513

2. [SECOND AUTHOR] Wardak S, **Raeside R**, Mandoh M, Partridge SR. Addressing Challenges in Creating a Community of Practice for Youth Advisors to Co-Design Health Research. *Proceedings of the 17th International Conference of the Learning Sciences* 2023; 2147-8

3. [FIRST AUTHOR] **Raeside R**, Han R, Todd A, Wardak S, Partridge S. Are nutrition and physical activity chatbots feasible and acceptable to adolescents? A systematic scoping review. *Digital Health Week* 2023; 2(1)

4. [FIRST AUTHOR] **Raeside R**, Redfern J, Partridge S. Co-Designing the Health4Me Text Message Intervention to Support and Improve Adolescent's Physical and Mental Health Outcomes: An Active Research Partnership With Adolescents. *Heart, Lung Circ* 2022; 31:S304

5. [FIRST AUTHOR] **Raeside R,** Jia S, Redfern J, Partridge S. Navigating the online world of lifestyle health information: an adolescent perspective. *Digital Health Week* 2022; 1(1)

Invited presentations

1. [NATIONAL ORAL] **Raeside R** (September 2024) Is social media effective for recruiting adolescents to the Health4Me Randomised Controlled Trial? Cardiovascular Research Network (CVRN) Rising Stars Seminar Series, Darlinghurst, NSW, Australia

2. [LOCAL ORAL] **Raeside R** (May 2024) Engaging young people in qualitative research, Sydney Health Literacy Lab – Community Panel Workshop, Virtual

3. [LOCAL ORAL] **Raeside R** (Nov 2023) Health4Me Study: Progress and benefits of youth engagement, SOLVE-CHD Research Showcase, Virtual

4. [NATIONAL ORAL] **Raeside R** (Jul 2023) Prioritising Adolescent Health in the Digital Age: Minimising Harm and Maximising Benefits of Technology, Health and Medical Research Office, Department of Health and Aged Care, Australian Government, Virtual

5. [LOCAL ORAL] **Raeside R** (Mar 2023) Unpack Research Challenges, SOLVE-CHD Retreat, Terrigal, NSW, Australia

6. [NATIONAL ORAL] **Raeside R** (Oct 2022) Consumer and community involvement in clinical trials: exploring the nitty gritty of consumer advisory panels, Sydney Health Partners, Virtual

7. [LOCAL ORAL] **Raeside R** (Mar 2021) Adolescents experience of lifestyle health in a digital world, Matilda Centre Research Showcase, Virtual

Presentations selected from abstract

1. [NATIONAL ORAL] **Raeside R**, Todd A, Partridge SR, Health4Me Team. Is social media effective for recruiting adolescents to the Health4Me RCT? Public Health Association of Australia, Australian Public Health Conference, Perth, Western Australia, Australia. 17-19th September 2024

2. [LOCAL ORAL] **Raeside R**. Accelerating implementation of adolescent digital health prevention programs in Australia. Faculty of Medicine and Health HDR Conference 2024, Sydney NSW, Australia. 24-25th July 2024

3. [LOCAL ORAL] **Raeside R**. Accelerating implementation of adolescent digital health prevention programs: Insights from Australian stakeholders. The University of Sydney, Sydney Nursing School Research Showcase, Sydney, NSW, Australia. 20th March 2024

4. [NATIONAL ORAL] **Raeside R**, Todd A, Partridge SR. Exploring barriers and enablers to implementation of digital health prevention programs for adolescents. Australian Association for Adolescent Health Conference 2023, Adelaide, South Australia, Australia. 8-10th November 2023

5. [NATIONAL ORAL] **Raeside R**. Involving a youth advisory group in a randomised controlled trial within Workshop 'Transformation of research: how can we revolutionise conventional approaches of research to enable engagement of adolescents as co-researchers?'. Australian Association for Adolescent Health Conference 2023, Adelaide, South Australia, Australia. 8-10th November 2023

6. [LOCAL POSTER, **Prize Awarded, People's Choice** $100] **Raeside R**. Barriers and Enablers of Recruitment into the Health4Me Study. Faculty of Medicine and Health HDR Conference 2023, Sydney NSW, Australia. 19-20th July 2023

7. [INTERNATIONAL ORAL – **Prize Session, Top 3 Abstracts in Young Adult Category**] **Raeside R**, Jia SS, Todd A, Hyun K, Singleton A, Gardner L, Champion K, Redfern J, Partridge SR. Effectiveness of digital health interventions targeting lifestyle risk behaviours on improving adolescent mental health or wellbeing: a systematic review with meta-analysis. International Society of Behavioural Nutrition and Physical Activity Annual Meeting 2023, Uppsala, Sweden. 14-17th June 2023

8. [NATIONAL POSTER] **Raeside R**, Todd A, Han R, Wardak S, Partridge SR. Are nutrition and physical activity chatbots feasible and acceptable to adolescents? A systematic scoping review. Digital Health and Informatics Network, Digital Health Week 2023, Online. 7-9th February 2023

9. [NATIONAL ORAL] **Raeside R**, Jia S, Hyun K, Singleton A, Gardner L, Champion K, Redfern J, Partridge SR. Effectiveness of digital health interventions targeting lifestyle risk factors on improving adolescent mental health or wellbeing: a systematic review. Australian Association for Adolescent Health Conference 2022, Melbourne, Victoria, Australia. 7-9th November 2022

10. [LOCAL ORAL] **Raeside R**. Just text me – improving the health of our teens one text at a time. Faculty of Medicine and Health HDR Conference 2022, Sydney NSW, Australia (3 Minute Thesis Semi-Final) 20th July 2022

11. [NATIONAL ORAL] **Raeside R**, Partridge SR, Redfern J, HEALTH4ME Team. 'Co-designing the Health4Me text message intervention to support and improve

adolescent's physical and mental health outcomes: an active research partnership with adolescents. Cardiac Society of Australia and New Zealand Annual Meeting 2022, Gold Coast, Queensland, Australia. 11-14th August 2022

12. [INTERNATIONAL ORAL] **Raeside R**, Partridge SR, Redfern J, HEALTH4ME Team. Co-design of health4me: a healthy lifestyle text message program for adolescents within Symposium 'Co-designing lifestyle behaviour research with young adults: opportunities and challenges'. International Society of Behavioural Nutrition and Physical Activity Annual Meeting 2022, Phoenix, Arizona, USA. 18-21st May 2022

13. [INTERNATIONAL POSTER] **Raeside R,** Jia S, Redfern J, Partridge SR. Navigating the online world of lifestyle health information: an adolescent perspective. International Union for Health Promotion and Education, 24th IUHPE World Conference 2022, Online. 15-19th May 2022

14. [NATIONAL ORAL] **Raeside R**, Jia S, Redfern J, Partridge SR. Navigating the online world of lifestyle health information: an adolescent perspective. Digital Health and Informatics Network, Digital Health Week 2022, Online. 15-17th February 2022

15. [NATIONAL ORAL] **Raeside R**, Redfern J, Partridge SR and the HEALTH4ME Team. Co-design of HEALTH4ME: a healthy lifestyle text message program for adolescents. Australian Association for Adolescent Health Research Showcase, Online. 23-26th November 2021

16. [LOCAL ORAL] **Raeside R**. Text message healthy lifestyle program to improve physical and mental health outcomes among adolescents. The University of Sydney, Digital Health ECR Research Showcase, Online. 24th November 2021

PEER-REVIEWED FUNDING AND PRIZES AWARDED

Scholarships

1. **SOLVE-CHD Completion Scholarship ($21,000)**, The University of Sydney, Australia, 2024

2. **SOLVE-CHD Postgraduate Scholarship ($32,000),** The University of Sydney, Australia, 2023

3. **CSANZ Research Scholarship ($36,863)**, Cardiac Society of Australia and New Zealand, Australia, 2022

4. **Postgraduate Research Scholarship in Digital Health, Youth and Nutrition ($35,000),** The University of Sydney, Australia, 2021

5. **Postgraduate Research Supplementary Scholarship in Cardiovascular Rehabilitation and Secondary Prevention ($10,000)**, The University of Sydney, Australia, 2021-2023

Grants

1. **Raeside R,** AI (2023), Medical Research Future Fund Consumer Led Research Grant. 'Adolescent-led transformation of preventive and public health research using citizen science' AUD $799,815

2. **Raeside R**, AI (2023), Medical Research Future Fund – Clinician Researchers Initiative: Nurses, Midwives and Allied Health Grant Opportunity. 'Adoption, impact

and sustainability of evidence-based practice into health care: Co-design and evaluation of projects, systems and processes' AUD $299,119

3. **Raeside R**, Singleton A. (2021) Student Co-curricular Grant, The University of Sydney "Podcast: We've done the research". AUD $2,000

4. Singleton A, Redfern J, Partridge SR, **Raeside R**. (2021) Sydney West Translational Cancer Research Centre. "Wellness after Cancer: Using text messages to support cancer survivors' heart health". AUD$15,000

Travel grants

1. **Raeside R.** (2024) Sydney Nursing School Conference Funding Scheme, The University of Sydney AUD $800

2. **Raeside R**. (2024) Postgraduate Research Support Scheme, The University of Sydney AUD $1,000

3. **Raeside R**. (2023) Postgraduate Research Support Scheme, The University of Sydney AUD $1,060

4. **Raeside R**. (2022) Postgraduate Research Support Scheme, The University of Sydney AUD $512.50

5. **Raeside R.** (2021) Charles Perkins Centre Early to Mid-Career Researcher Travel Funding Award, The University of Sydney, AUD $750

Awards and prizes

1. **Raeside R**. (2024) International Society of Behavioural Nutrition and Physical Activity Young Adult Special Interest Group: Best Publication Award 2023 (Post-Graduate Student Category) for “Striking the right balance: co-designing the Health4Me healthy lifestyle digital health intervention with adolescents” in *Research Involvement and Engagement*

2. **Raeside R**. (2024) Top 4 National Finalist 2024 Public Health Student Think Tank Competition, Public Health Association of Australia (Top 4 of 19 applicants)

3. **Raeside R**. (2023) People’s Choice Award for Best Poster, Faculty of Medicine and Health HDR Conference, The University of Sydney, AUD$100

4. **Raeside R**. (2023) Top 3 Finalist in Young Adults Special Interest Group for Conference Award, International Society of Behavioural Nutrition and Physical Activity, Uppsala, Sweden

5. **Raeside R**. (2021) Charles Perkins Centre Early to Mid-Career Researcher Professional Development Award, The University of Sydney, AUD $500

MEDIA ARISING FROM THESIS

1. September 23, 2024. Issa M, Croucher I, Todd A, Partridge SR, **Raeside R.** The adolescent social media ban alone won't work. Here's what will. Public Health Association of Australia Intouch. https://intouchpublichealth.net.au/the-adolescent-social-media-ban-alone-wont-work-heres-what-will/

2. December 4, 2023. **Raeside R**, Partridge SR, Todd A, Wardak S, Dogra S. Empowering Australia's youth in the digital age. MJA InSight+ https://insightplus.mja.com.au/2023/47/empowering-australias-youth-in-the-digital-age/

3. May 30, 2023. Conference Award Shortlist. International Society of Behavioural Nutrition and Physical Activity Young Adult Special Interest Group Newsletter. (Attached in Appendix G)

4. March 17, 2023. Todd A, **Raeside R**, Partridge SR. Prioritising Adolescent Health: Working with Young People to Build a Healthier and More Inclusive Future. Public Health Association of Australia Intouch. https://intouchpublichealth.net.au/prioritising-adolescent-health-working-with-young-people-to-build-a-healthier-and-more-inclusive-future/

5. January 10, 2023. Five minutes with **Rebecca Raeside**, PhD. Digital Health and Informatics Network Newsletter. (Attached in Appendix G)

6. May 11, 2022. Partridge SR, **Raeside R**, Mandoh M, Cheng HL. Putting a spotlight on issues that affect the wellbeing of young people. Croakey.

https://www.croakey.org/putting-a-spotlight-on-issues-that-affect-the-wellbeing-of-young-people/

7. May 2, 2022: University of Sydney media press release “Youth outline top health concerns on scientific stage” https://www.sydney.edu.au/news-opinion/news/2022/05/02/youth-outline-top-health-concerns-on-scientific-stage.html

8. April 30, 2022: Sydney Morning Herald (SMH) ‘Left to our own devices’: Lockdown kids got two years of screens, influencers and junk food ads. https://www.smh.com.au/national/nsw/left-to-our-own-devices-lockdown-kids-got-two-years-of-screens-influencers-and-junk-food-ads-20220429-p5ah65.html

9. April 2022. CSANZ Research Scholarship Winners: **Rebecca Raeside** and Thomas Meredith. On The Pulse – The official newsletter of the Cardiac Society of Australia and New Zealand. Vol 35(1); p.9 (Attached in Appendix G)

AIMS OF THIS THESIS

The overall aim of this thesis is to provide evidence to advance adolescent health promotion in the digital era. The overall thesis structure is represented in a schematic on page 1. Specific aims of this thesis are to:

1. To synthesize the literature on adolescent health promotion in the digital era through a state-of-the-art review **[Chapter One (Part 2)]**
2. Systematically review the literature to evaluate how effective digital health interventions targeting lifestyle risk behaviors are in improving mental health or wellbeing among adolescents **[Chapter Two]**
3. To evaluate adolescents' perceptions on the use of contemporary digital platforms (websites, social media platforms, smartphone apps) to seek lifestyle heath information or advice using focus groups **[Chapter Three]**
4. To co-design a bank of text messages to promote a healthy lifestyle which are useful, acceptable, and engaging for adolescents aged 12–18 years old using an iterative, mixed-methods design with consumer partnership **[Chapter Four]**
5. Develop a randomised controlled trial protocol of a healthy lifestyle text message intervention called Health4Me, which aims to improve adolescent's physical activity or nutrition behaviours compared to usual care at 6-months **[Chapter Five]**
6. To examine the effectiveness and cost of various digital recruitment strategies for recruiting adolescents to the Health4Me RCT, evaluate the progression of participants from screening to enrolment and explore factors associated with non-participation using social media data, screening, and recruitment logs **[Chapter Six]**
7. To evaluate stakeholders' support for, and perspectives on potential public health impact of digital health prevention programs for adolescents and potential pathways for future implementation using semi-structured interview data **[Chapter Seven]**

Chapter One

Introduction

Chapter Two

Systematic Review with Meta-Analysis

Chapter Three

Qualitative Study with Adolescents

HEALTH4ME

Chapter Four

Co-Design of Health4Me

Chapter Five

Health4Me RCT Protocol

Chapter Six

Health4Me Recruitment

Chapter Seven

Qualitative Study with Stakeholders

Chapter Eight

Discussion and Conclusions

CHAPTER ONE: Introduction (Part 1)

ADOLESCENCE

Adolescence (10 to 24 years of age) is a transitional phase of growth between childhood and adulthood. Adolescence begins with the onset of puberty (1), a developmental transition which is shaped by rapid biological, cognitive, and psychosocial growth. The pace these changes occur is second only to infancy (2). Pubertal changes include a growth spurt, emergence of secondary sexual characteristics, achievement of reproductive maturity, and profound psychological changes (1). These biological, cognitive, and psychosocial changes affect individuals differently and are explained below in detail.

Biological changes

At a biological level, puberty involves a series of changes at neural and endocrine levels, which result in a series of physical changes in the body. The maturation of the hypothalamic-pituitary-adrenal axis (HPA), or *adrenarche*, occurs between ages six and nine (3). HPA maturation increases the levels of adrenal androgens, which peak during a person's early 20s. This rise in adrenal androgens contributes to changes which affect both sexes, including a growth spurt, changes in skin and body odour, and the growth of pubic and axillary hair (1).

Gonadarche begins between ages nine and 11, involving reactivation of the hypothalamic-pituitary-gonadal axis (HPG), which triggers a rise of gonadal steroid hormones and is responsible for the maturation of secondary sex characteristics, and ultimately the achievement of reproductive maturity (3). In females, the changes that occur include the accumulation of body fat, appearance of breasts, and menarche; while changes within males include the enlargement of testes, increased penis size, and the growth of facial hair (1).

Though growth and development are largely driven by biological process, evidence also suggests that social environments play a role this phase of life (4); thus the timing, length, and experience of puberty is variable, and can be culturally dependent (5).

Cognitive changes

Adolescence is a period of substantial brain development. Though the increase in volume is relatively steady, there are significant changes in gray and white matter distribution. White matter increases approximately 12% from age four to 22, with a greater increase in males than females (6). Gray matter increases steadily in volume to reach a peak in adolescence – which varies by lobes of the brain – followed by a decline in volume across the lifespan (6). As with all phases of adolescent development, there is variability between ages and sexes at which these changes occur (7, 8).

Along with changes in brain composition, there are also developments in cognition and communication across three key areas: executive functioning, social cognition, and language (9). Executive functions include formulating goals, planning, and carrying out plans effectively, which are vital for independent, creative, and socially-constructive behaviour (10). Social cognition refers to a set of cognitive processes that are thought to be specific to social functioning (11), including recognising emotions and perceptions about the mental state of other individuals and their behaviour (12). Developments in language form, content, and use allow for skills that are required for communication in diverse contexts over time (13).

Psychosocial changes

This development in executive functioning, social cognition, and language leads to changes in behaviour across adolescence, linked to the changes in brain development described earlier (14). Adolescents develop the ability to interpret the perspectives of others, perform abstract thinking and introspection, develop coping skills, establish a system of values and morals, and place greater importance on peer relationships (4). Though there are advantages which signal complete maturation in executive functioning, adolescence is also a period of vulnerability. Abstract thinking can predispose adolescents to risk-taking and impulsive behaviour (15). Additionally, changes in social environments can lead to heightened social sensitivity, including being susceptible to peer-influences and self-consciousness (16). These biological, cognitive, and psychosocial changes interact in each individual to influence growth, educational attainment, self-esteem, peer relationships, and family environments (17) – all of which have profound impacts on their overall health and wellbeing.

The World Health Organization (WHO) defines ‘adolescents’ as those from ages 10 to 19, ‘youth’ from ages 15 to 24, and ‘young people’ from ages 10 to 24 (18). Due to differences in age definitions, the terms ‘adolescents’, ‘youth’, and ‘young people’ are used interchangeably in the literature, yet all refer to this important developmental period of life. More recent definitions have called for the definition of ‘adolescence’ to expand from ages 10 to 24 (19), which aligns more closely with the continued growth and development which extends through biological, cognitive, and psychosocial domains during this time (1). In addition, modern society has thrust emerging commercial actors, social forces, and digital media upon adolescents which all play a role in growth and development across these years. Throughout this thesis, the term ‘adolescents’ will be used to broadly refer to those aged 10 to 24. Where statistics are presented, the age range will be included.

Today's generation of adolescents is the largest generation in history. The number of 10- to 19-year-olds comprise 16% of the world's population, amounting to 1.3 billion (20), and a total of 1.8 billion 10- to 24-year-olds (21). The number of adolescents worldwide is expected to rise through 2050, especially in low- and middle-income countries (LMIC) (18). In Australia, the latest census data (2021) indicate there are approximately 4.6 million adolescents (10 to 24 years old), making up 18.2% of the total Australian population and 30% of the Indigenous Australian population (22). 52% of Australia's population of adolescents (15 to 24 years old) were male and 48% were female (23). In terms of sexuality and gender, the most recent data in Australia found 17.7% of 16- to 24-year-olds identify with a diverse sexuality and 2.3% with a diverse gender (24). According to Australian data from 2022, 75% of all adolescents (15 to 24 years old) lived in major cities (23), 20% lived in the lowest socioeconomic areas (23) and 21% were born overseas (25). The adolescent population in Australia is expected to grow to 5.1 million by 2066 (26) and make up approximately 12% of the population. Given the complexities of growth and development in the adolescent period and the large adolescent population in Australia, it is vital that adolescence is a time of promoting good health and wellbeing to carry throughout life.

ADOLESCENT HEALTH AND WELLBEING

The health and wellbeing status in adolescence lays the foundation for health and wellbeing in adulthood (27-29). Investing in adolescent health can yield a triple dividend – today, into adulthood, and for the next generation (30). The period of adolescence offers a vital time for promoting health and preventing development of non-communicable diseases (NCDs) such as cardiovascular disease, type 2 diabetes, and some types of cancer (31, 32). NCDs are the leading cause of mortality worldwide, accounting for 74% of all deaths globally (33). Current efforts to address NCDs focuses largely on the adult population (27), as adolescents are often considered healthy. Yet, among adolescents, multiple health behaviours emerge which puts them at risk for developing NCDs later in life (34-36). Key health behaviours

which increase the risk of developing NCDs in adulthood include physical inactivity, poor nutrition, excess sedentary time, poor sleep, excess alcohol consumption, smoking, and poor mental health.

Additionally, adolescent development drives changes in disease burden due to an increase in risk-taking behaviours and social influences, which includes the emergence of substance use disorders, mental disorders, alcohol use, and obesity (37). This provides specific challenges for promoting health and wellbeing within adolescence. Poor nutrition and physical inactivity are discussed next, which are the key health risk behaviours for NCD development in adolescence.

Adequate nutrition

Adequate nutrition in adolescence is vital for optimal growth and development, impacting the timing and pattern of puberty, as well as the risk for NCDs (38). The growth and development of adolescence demands increased energy, macronutrient, and micronutrient requirements (39). Global data show adolescents are consuming less fruit and vegetables (3.18 serves/day) (40) than what is recommended by the WHO (5 serves/day) (41). However, there is wide variability in subpopulations (40), including a lack of representative, detailed dietary data from sub-Saharan Africa, South Asia, and low-income countries (42). In 2022, only 2.8% of adolescents in Australia between 12 to 17 years old met both the fruit and vegetable recommendations (43). Research shows that unhealthy dietary patterns in adolescents from high-income countries are associated with those of low socioeconomic status, yet the same is not true of adolescents from LMICs (44). Nutritional status of adolescents is impacted by complex interactions of social, environmental, and behavioural factors which will be explored.

Globally, malnutrition is a significant problem for adolescents. The number of adolescents who are underweight (45), have micronutrient deficiencies (46), and food insecurity (47) persist in many regions (38). Additionally, urbanisation (48), climate change (49), and a shift in food systems (50, 51) have led to the transformation of adolescent food environments. Access to, and consumption of, ultra-processed foods with higher caloric and decreased nutritional value is on the rise (52). The marketing of these foods by commercial actors and the tactics they use influence adolescents' food choices (53). The consequences of these changing contexts can influence adolescent growth and development with profound impacts on height and adiposity (38). This has led to an increase in adolescent overweight and obesity in both high-income and LMICs (54, 55).

As described earlier, biological, cognitive, and psychosocial changes during adolescence also impact upon their nutritional status. As adolescents begin to move away from their family unit, they become more independent in their food choices, are influenced by their peers, and are less likely to pick healthy foods (56). However, choices are also influenced by food availability (both within and external to the home), convenience, knowledge of food content (including benefits and risks), and parental influence on eating behaviours (57). In addition, the growth spurt which happens during adolescence has specific energy and nutrition requirements, resulting in appetite changes (58). Despite adolescence being a time of transformative growth, second only to infancy, it is concerning that adolescent nutrition has been overlooked as a global priority (59). Many intervention studies emphasise the importance of micronutrient supplementation (60, 61), whilst ignoring the complex interplay of factors which influence adolescent nutrition. As a result, long-standing nutritional problems persist amongst adolescents whilst overweight and obesity rates are on the rise. For future interventions to be successful, they must consider the many factors which influence adolescent nutrition and provide education to ensure that adolescents have information available to make healthy food choices.

Physical activity

The health benefits of physical activity are widely recognised (62, 63). Physical activity can also achieve important cross-sector goals e.g., increased active transport to reduce air pollution (64). Yet, it is estimated that 5.3 million deaths per year are attributed to physical inactivity (65), which is now recognised as a global pandemic (66). For adolescents (up to 18 years old), the WHO recommends 60 minutes per day of moderate to vigorous intensity physical activity, yet the recommendations change for those aged over 18 years (67). Current global data among adolescents demonstrates that in 2016, only 19% of 11- to 17-year-olds achieved recommended physical activity levels, with more females being inactive than males (84.7% vs 77.6%, respectively) (68, 69). Physical inactivity is more common in high-income countries than low-income countries (68) yet shifts in this may occur over time as decreases in occupational physical activity and increases in leisure time physical activity are being observed (68, 70). In Australia, based on 2022 data, only 11% of 13- to 14-year-olds and 5.6% of 15- to 17-year-olds met the physical activity guidelines (43), with males more likely to meet the guidelines than females (43).

Importantly, physical activity levels have been shown to decline during adolescence (71, 72). Given we have evidence that physical activity levels track consistently from adolescence into adulthood (73), combined with an aging population, this will impact the growth of NCDs in the future. Sedentary behaviour and screen-based activities are large contributing factors to the decline in physical activity, which have detriments to both health and wellbeing (74, 75). Global surveillance data from the Global Student Health Survey shows that 25% of boys and 24% of girls 13 to 15 years old report sitting for greater than three hours per day, in addition to school and homework (76). Rates in high-income countries were twice that of LMICs (76). Other factors found to contribute to declines in physical activity during adolescence include

socioeconomic status, home environment, negative social validation, lack of social support, and access barriers (77-79).

Interventions have the potential to increase current physical activity rates among adolescents, which are occurring across schools, social and digital environments, and within communities (80). A 2007 systematic review found strong evidence for school-based interventions with the involvement of family or community and multicomponent interventions for increasing physical activity (81). Various limitations in study design and reporting across included studies were noted, such as lack of reported information on randomisation and blinding, short follow-up duration, and lack of precision in physical activity measurement (81). An updated umbrella review summarised the evidence since 2012 and found that school-based interventions were largely unsuccessful in changing physical activity behaviours, mostly due to poor implementation (82, 83). However, multi-component interventions appear to be more successful than single-component, school-based interventions (84). Emerging evidence of digitally-delivered interventions to promote physical activity show promise in the short term, which warrant further exploration (85, 86). Despite randomised controlled trial evidence, this umbrella review revealed that limited LMICs were included in the reviews and interventions targeted younger adolescent populations (10 to 14 years old). In addition, effect sizes were generally small and non-significant. Therefore, there is an underrepresentation of 15- to 19-year-olds and LMICs in physical activity research.

Associations and clustering of health risk behaviours

Research shows that the number of health risk behaviours increase with age and co-occur as risk behaviour clusters (87-89). This is cause for concern during adolescence, as it is also a crucial period for psychopathology with half of all mental health conditions emerging by age 14 (90). Significant relationships have been established between unhealthy dietary

patterns and poor mental health among adolescents (91). In addition, evidence shows that physical activity has the potential to reduce symptoms of depression and anxiety (92), and significant positive associations exist between physical activity and mental health status in adolescents (93, 94). These findings demonstrate that keeping a healthy diet and being physically active may be protective towards mental health and wellbeing among adolescents.

Associations have also been demonstrated between other health risk behaviours and poor mental health. Excessive screen time and not meeting sleep recommendations are associated with mental health problems among adolescents (95, 96). Strong associations have also been found between harmful alcohol use (97), tobacco use (98), e-cigarette use (99), and mental health problems. Limitations among these studies include the fact that they are mostly cross-sectional or survey studies with limited follow-up. Future longitudinal or experimental studies are needed in these areas to confirm cause and effect relationships. Despite this, there is a clear need for targeted strategies and interventions for adolescents which focus on positive health behaviours that are protective for both physical and mental health. However, these strategies must also aim to address health determinants across multiple levels (32).

IMPACT OF HEALTH RISK BEHAVIOURS DURING ADOLESCENCE

It is widely recognised that NCDs are primarily attributed to health risk behaviours which often emerge during adolescence. This can lead to morbidity and mortality from overweight and obesity, cardiovascular disease, and poor mental health (31, 32). Without intervention, today's adolescents are at risk of developing NCDs and puts further pressure on our already-strained health system.

Overweight and obesity

The prevalence of overweight and obesity increases significantly in mid-adolescence (100). This is seen globally with higher rates of overweight and obesity in developed than developing countries, and higher rates among males than females (101). In Australia, 27% of adolescents were overweight or obese in 2022, which has increased in the last 10 years (43). This is consistent with global data showing a significant upward trend in overweight and obesity (102). Without intervention, this generally persists into adulthood and impacts upon morbidity and mortality in later life (103, 104). Morbidities attributable to overweight and obesity include type 2 diabetes (105), metabolic syndrome (106), and several cardiovascular risk factors (e.g., hypertension, dyslipidemia, atherosclerosis) (107, 108). Adolescents with overweight and obesity are also exposed to weight-related stigma – which stereotypes individuals as lazy, lacking discipline, or unmotivated (109). Weight stigma causes harm through bullying, social isolation, changes in dietary behaviours, and avoidance of healthcare services (110), all of which cause further barriers to healthy behaviour change. Interventions that focus on the primary prevention of overweight and obesity are needed, yet current evidence demonstrates that interventions are not effective in reducing body mass index or increasing physical activity (111). Despite systematic review evidence, the quality of the evidence was rated extremely low. Interventions are needed which operate across levels of influence (e.g., public policy, community) and address weight stigma and determinants of health (e.g., social, commercial).

Cardiovascular disease

Cardiovascular disease is the leading cause of mortality worldwide, claiming nearly 18 million lives annually (33). Multiple studies including large datasets have uncovered links between adolescent health status and development of cardiovascular disease. The National Health and Nutrition Examination Surveys (NHANES) 2005-2010 examined cardiovascular health components of 4673 American adolescents (12 to 19 years old) and found that there

was a low prevalence of ideal cardiovascular health behaviours, particularly physical activity and dietary intake (112). Similarly, the Cardiovascular Risk in Young Finns Study followed 1143 Finnish children and adolescents for 21 years to study the change in cardiovascular health status from childhood to adulthood. Major findings from the study include that a change in ideal health status from childhood to adulthood was an independent predictor of adult pulse wave velocity (a marker of cardiovascular disease) (113), and that exposure to cardiovascular risk factors early in life may contribute to the development of atherosclerosis (114). These studies are cross-sectional and observational in nature, which cannot establish causality. Overall, findings suggest that to prevent cardiovascular disease in adulthood, it is vital to prioritise optimal cardiovascular health in adolescence (115).

Poor mental health

Development of good mental health during adolescence is important for good health and wellbeing to lead fulfilling and productive lives as adults. Globally, 14% of 10- to 19-year-olds experience a mental disorder with anxiety, depression, and behavioural disorders as the leading contributors (116). In Australia, the rates of mental disorders are on the rise. In 2013-14, 20% of 11- to 17-year-olds had high or very high levels of psychological distress (117). In 2018, rates of psychological distress had risen to 32% and in 2020 they were sitting at 34% (118). Many potential drivers of increases in poor mental health during adolescence have been proposed including: increases in social media use (119), cost of living (120), student debts (121), environmental crises worries (122), and a reduction in key health behaviours (e.g., physical activity, dietary intake) (91, 96). Interventions to modify key health behaviours are often part of treatment protocols for adolescents with mental disorders (123, 124). However, it is unknown whether maintaining key health behaviours throughout adolescence can prevent the development of mental disorders.

Furthermore, emerging research has been conducted to understand whether adverse outcomes from key health behaviours (e.g., cardiovascular disease) can be prevented by maintaining good mental health and wellbeing, shifting the focus from the role of psychological distress. Using data from the National Longitudinal Study of Adolescent Health, the authors demonstrate that adolescents with more psychological assets (e.g., optimism, happiness, self-esteem, belongingness, and feeling loved) were likely to have better cardiometabolic health in adulthood (125). Another study using the same data set also show that those who had higher levels of belonging (one of five dimensions of psychological wellbeing) in adolescence were more likely to maintain cardiometabolic health throughout adulthood (126). This research further demonstrates the importance of the development of positive social relationships in adolescence and their impact upon health outcomes in adulthood.

HEALTH RISK BEHAVIOUR MANAGEMENT IN ADOLESCENTS

The Australian government has an increasing focus on the need for the management of health risk behaviours among adolescents. The National Action Plan for the Health of Children and Young People 2020-30 details ‘addressing chronic conditions and preventive health’ as a priority action area (127), and the National Preventive Health Strategy 2021-30 includes focus areas ‘improving access to and consumption of a healthy diet’, ’increasing physical activity’, and ‘promoting and protecting mental health’ (128). Yet, there is a continued lack of funding to preventive health in the federal budget, despite evidence demonstrating the economic benefits (129). In 2018-19, the total investment in preventive health was less than 2% of the health budget (130). In contrast, the total health system spending attributable to avoidable risk factors was $24 billion in 2018-19, equating to around 12% of the overall health budget (131). Without preventive health intervention, this amount is only set to increase. In addition, there is a lack of strategies which are freely available to adolescents to support health risk behaviour management. An analysis of obesity strategies

in New South Wales demonstrated that there are 22 strategies focusing on good nutrition and physical activity (initiatives, guidelines, or policies). Of these strategies, most were located within in-person settings including healthcare, high schools, and community settings (132). No other studies were available to analyse existing strategies from other states from across Australia. Supporting adolescents to improve key health risk behaviours requires a combination of evidence-based interventions and public health policy which enables healthy decision making.

Primary health care is a crucial factor to address the burden of NCDs. However, research demonstrates that primary health care is not prepared to address the growing burden of NCDs (133). The Australian primary health care model focuses on acute and episodic care, which is ineffective for NCDs that are chronic and complex conditions (134). In addition, those from priority populations, with chronic conditions, and living in rural and remote areas, have ongoing issues with primary health care including poor access and unmet needs (135). This is only set to drive health inequalities. The ability to address these ongoing issues and shift the health care system towards prevention is an immense challenge. To overcome this, novel strategies are needed which aim to relieve the pressure off primary health care and address health inequalities.

A wide range of interventions have been developed and tested to improve health risk behaviours and encourage health-promoting behaviours among adolescents through education (136). Many of these are school-based, community-based, and may include parent and/or family involvement (137). More recently, there has been exponential growth in the use of digital strategies that aim to empower individual behaviour change to improve health risk behaviours. The literature on adolescent health promotion in the digital era is explored broadly in Chapter 1.2. In brief, digital strategies hold promise for diet and physical

activity behaviour change where interventions include education, goal setting, self-monitoring and parental involvement. However, most evidence relates to websites and further research into contemporary digital health interventions is warranted (137).

Importantly, terminology in this area has evolved over the course of producing this thesis, with a shift in the use of the word ‘lifestyle’ in the prevention of NCDs (138). The word ‘lifestyle’ implies personal responsibility by definition. However, there are powerful commercial and social forces which also influence one’s health. Thus, earlier published chapters in this thesis use ‘lifestyle’, and chapters produced later avoid its use altogether. The word lifestyle is still commonly used within health research; for example, in a recent grant call for the Medical Research Futures Fund ‘2024 MRFF Maternal Health and Healthy Lifestyles’. Additionally, the definition of ‘lifestyle’ behaviours varies throughout this thesis. Given the significant associations between nutrition and physical activity and mental health status among adolescents, these health risk behaviours are focused on in each chapter. Other chapters focus on additional health risk behaviours, which were selected as they were most relevant to the policy context at the time the studies were undertaken, or those which adolescents identified as most relevant.

CONCLUSION

Chapter One so far has introduced the developmental period of adolescence, the importance of optimal health and wellbeing status during this time, the potential impacts of poor health and wellbeing status during adolescence, and the need for the management of health risk behaviours to improve the health and wellbeing for today’s generation of adolescents and generations to come. The remainder of this chapter is a published state-of-the-art review aiming to synthesise the literature on adolescent health promotion in the digital era.

REFERENCES

1. National Academies of Sciences, Engineering, and Medicine; Health and Medicine Division; Division of Behavioral and Social Sciences and Education; Board on Children, Youth, and Families; Committee on the Neurobiological and Socio-behavioral Science of Adolescent Development and Its Applications. Backes EP, Bonnie RJ, editors. The promise of adolescence: Realizing opportunity for all youth. Washington (DC): National Academies Press (US); 2019. doi: 10.17226/25388

2. National Research Council (US) and Institute of Medicine (US) Forum on Adolescence. Kipke MD, editor. Adolescent development and the biology of puberty: Summary of a workshop on new research. Washington (DC): National Academies Press (US); 1999. doi: 10.17226/9634

3. Sisk CL, Foster DL. The neural basis of puberty and adolescence. Nat Neurosci. 2004;7(10):1040-7.

4. Remschmidt H. Psychosocial milestones in normal puberty and adolescence. Horm Res. 1994;41(Suppl. 2):19-29.

5. Gowers S. Development in adolescence. Psychiatry. 2005;4(6):6-9.

6. Giedd JN, Blumenthal J, Jeffries NO, Castellanos FX, Liu H, Zijdenbos A, et al. Brain development during childhood and adolescence: A longitudinal MRI study. Nat Neurosci. 1999;2(10):861-3.

7. Steinberg L. Cognitive and affective development in adolescence. Trends Cogn Sci. 2005;9(2):69-74.

8. Peters M, Jäncke L, Staiger JF, Schlaug G, Huang Y, Steinmetz H. Unsolved problems in comparing brain sizes in Homo sapiens. Brain Cogn. 1998;37(2):254-285.

9. Ciccia AH, Meulenbroek P, Turkstra LS. Adolescent brain and cognitive developments: Implications for clinical assessment in traumatic brain injury. Top Lang Disord. 2009;29(3):249-265.

10. Lezak MD. The problem of assessing executive functions. Int J Psychol. 1982;17(1-4):281-297.

11. Schulkin J. Roots of social sensibility and neural function. Cambridge, Massachusetts: MIT Press; 2000.

12. Arioli M, Crespi C, Canessa N. Social cognition through the lens of cognitive and clinical neuroscience. Biomed Res Int. 2018;2018:4283427.

13. Nippold M. Later language development: The school-age and adolescent years. 2nd ed. Austin, TX: Pro-Ed; 1998.

14. Barnea-Goraly N, Menon V, Eckert M, Tamm L, Bammer R, Karchemskiy A, et al. White matter development during childhood and adolescence: A cross-sectional diffusion tensor imaging study. Cereb Cortex. 2005;15(12):1848-1854.

15. Sanders RA. Adolescent psychosocial, social, and cognitive development. Pediatr Rev. 2013;34(8):354-358; quiz 358-359.

16. Blakemore SJ. KL.01 – Development of the adolescent brain: implications for executive function and social cognition. In European neuropsychopharmacology: Abstracts of the ECNP workshop for junior scientists in Europe; 2017 March 15-18; Nice, France. 2018;28:S1.

17. Richter LM. Studying adolescence. Science. 2006;312(5782):1902-1905.

18. World Health Organization. Adolescent health [Internet]. 2024. cited 2024 Jul 3]. Available from: https://www.who.int/health-topics/adolescent-health#tab=tab_1

19. Sawyer SM, Azzopardi PS, Wickremarathne D, Patton GC. The age of adolescence. Lancet Child Adolesc Health. 2018;2(3):223-228.

20. UNICEF. Adolescents [Internet]. 2024. cited 2024 Jul 3]. Available from: https://data.unicef.org/topic/adolescents/overview

21. PMNCH. Agenda for action for adolescents [Internet]. 2023. cited 2024 Mar 20]. Available from: https://www.1point8b.org/agendaforactionforadolescents

22. Australian Bureau of Statistics. Snapshot of Australia: ABS [Internet]. 2021. cited 2022 May 3]. Available from: https://www.abs.gov.au/statistics/people/people-and-communities/snapshot-australia/2021#cite-window1

23. Australian Institute of Health and Welfare. Health of young people. Canberra, Australia; 2024. Available from: https://www.aihw.gov.au/reports/children-youth/health-of-young-people

24. Higgins DJ, Lawrence D, Haslam DM, Mathews B, Malacova E, Erskine HE, et al. Prevalence of diverse genders and sexualities in Australia and associations with five forms of child maltreatment and multi-type maltreatment. Child Maltreat. 2024;12:10775595231226331.

25. Australian Bureau of Statistics. Estimated resident population, country of birth, age and sex — as at 30 June annually — 1996 onwards: ABS [Internet]. 2023. cited 2024 Jul 7]. Available from: https://explore.data.abs.gov.au/vis?tm=estimated%20resident%20country%20of%20birth&pg=0&df[ds]=ABS_ABS_TOPICS&df[id]=ERP_COB&df[ag]=ABS&df[vs]=1.0.0&pd=2005%2C&dq=TOT.3..AUS.A&ly[cl]=TIME_PERIOD&ly[rw]=COUNTRY_BIRTH

26. Australian Bureau of Statistics. Population projections, Australia: ABS [Internet]. 2023. cited 2024 Jul 7]. Available from: https://www.abs.gov.au/statistics/people/population/population-projections-australia/latest-release

27. Sawyer SM, Afifi RA, Bearinger LH, Blakemore SJ, Dick B, Ezeh AC, et al. Adolescence: A foundation for future health. Lancet. 2012;379(9826):1630-1640.

28. Azzopardi PS, Hearps SJC, Francis KL, Kennedy EC, Mokdad AH, Kassebaum NJ, et al. Progress in adolescent health and wellbeing: Tracking 12 headline indicators for 195 countries and territories, 1990-2016. Lancet. 2019;393(10176):1101-1118.

29. The Lancet. Health and wellbeing in adolescence and early adulthood. Lancet. 2019;393(10174):847.

30. Patton GC, Sawyer SM, Santelli JS, Ross DA, Afifi R, Allen NB, et al. Our future: A Lancet commission on adolescent health and wellbeing. Lancet. 2016;387(10036):2423-2478.

31. Tohi M, Bay JL, Tu'akoi S, Vickers MH. The developmental origins of health and disease: Adolescence as a critical lifecourse period to break the transgenerational cycle of NCDs-A narrative review. Int J Environ Res Public Health. 2022;19(10):6024.

32. Akseer N, Mehta S, Wigle J, Chera R, Brickman ZJ, Al-Gashm S, et al. Non-communicable diseases among adolescents: Current status, determinants, interventions and policies. BMC Public Health. 2020;20(1):1908.

33. World Health Organization. Noncommunicable diseases [Internet]. 2023. cited 2023 Nov 7]. Available from: https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases

34. Blum RW. Young people: Not as healthy as they seem. Lancet. 2009;374(9693):853-854.

35. Beaglehole R, Bonita R, Horton R, Adams C, Alleyne G, Asaria P, et al. Priority actions for the non-communicable disease crisis. Lancet. 2011;377(9775):1438-1447.

36. Gore FM, Bloem PJN, Patton GC, Ferguson J, Joseph V, Coffey C, et al. Global burden of disease in young people aged 10–24 years: A systematic analysis. Lancet. 2011;377(9783):2093-2102.

37. Sanci L, Webb M, Hocking J. Risk-taking behaviour in adolescents. Aust J Gen Prac. 2018;47:829-834.

38. Norris SA, Frongillo EA, Black MM, Dong Y, Fall C, Lampl M, et al. Nutrition in adolescent growth and development. Lancet. 2022;399(10320):172-184.

39. Lassi Z MA, Bhutta Z. Nutrition in middle childhood and adolescence. In: Bundy DAP SN, Horton S, et al., editors. Child and adolescent health and development. 3rd ed. Washington (DC): The International Bank for Reconstruction and Development / The World Bank; 2017.

40. Beal T, Morris SS, Tumilowicz A. Global patterns of adolescent fruit, vegetable, carbonated soft drink, and fast-food consumption: A meta-analysis of global school-based student health surveys. Food Nutr Bull. 2019;40(4):444-459.

41. World Health Organization. Healthy diet [Internet]. 2020. cited 2024 Jul 7]. Available from: https://www.who.int/news-room/fact-sheets/detail/healthy-diet

42. Demmler KM, Beal T, Ghadirian MZ, Neufeld LM. Characteristics of global data on adolescent's dietary intake: A systematic scoping review. Curr Dev Nutr. 2024;8(1):102054.

43. Australian Bureau of Statistics. National Health Survey Canberra: ABS [Internet]. 2022. cited 2024 Apr 29]. Available from: https://www.abs.gov.au/statistics/health/health-conditions-and-risks/national-health-survey/2022

44. Hinnig PDF, Monteiro JS, De Assis MAA, Levy RB, Peres MA, Perazi FM, et al. Dietary patterns of children and adolescents from high, medium and low human development countries and associated socioeconomic factors: A systematic review. Nutrients. 2018;10(4):436.

45. Christian P, Smith Emily R. Adolescent undernutrition: Global burden, physiology, and nutritional risks. Ann Nutr Metab. 2018;72(4):316-328.

46. Viteri FE, Gonzalez H. Adverse outcomes of poor micronutrient status in childhood and adolescence. Nutr Rev. 2002;60(suppl_5):S77-S83.

47. Dush JL. Adolescent food insecurity: A review of contextual and behavioral factors. Public Health Nurs. 2020;37(3):327-338.

48. Kuddus MA, Tynan E, McBryde E. Urbanization: A problem for the rich and the poor? Public Health Rev. 2020;41:1.

49. Fanzo JC, Downs SM. Climate change and nutrition-associated diseases. Nat Rev Dis Primers. 2021;7(1):90.

50. Agostoni C, Baglioni M, La Vecchia A, Molari G, Berti C. Interlinkages between climate change and food systems: The impact on child malnutrition-narrative review. Nutrients. 2023;15(2):416.

51. Ambikapathi R, Schneider KR, Davis B, Herrero M, Winters P, Fanzo JC. Global food systems transitions have enabled affordable diets but had less favourable outcomes for nutrition, environmental health, inclusion and equity. Nature Food. 2022;3(9):764-779.

52. Wang L, Martínez Steele E, Du M, Pomeranz JL, O'Connor LE, Herrick KA, et al. Trends in consumption of ultraprocessed foods among US youths aged 2-19 years, 1999-2018. JAMA. 2021;326(6):519-530.

53. Tsochantaridou A, Sergentanis TN, Grammatikopoulou MG, Merakou K, Vassilakou T, Kornarou E. Food advertisement and dietary choices in adolescents: An overview of recent studies. Children (Basel). 2023;10(3):442.

54. Johnson BJ, Bell LK, Zarnowiecki D, Rangan AM, Golley RK. Contribution of discretionary foods and drinks to Australian children's intake of energy, saturated fat, added sugars and salt. Children (Basel). 2017;4(12):104.

55. Abarca-Gómez L, Abdeen ZA, Hamid ZA, Abu-Rmeileh NM, Acosta-Cazares B, Acuin C, et al. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. Lancet. 2017;390(10113):2627-2642.

56. Seymour M HSL, Huang Y L. Inappropriate dieting behaviors and related lifestyle factors in young adults: Are college students different? J Nutr Educ. 1997;29:21-26.

57. Neumark-Sztainer D, Story M, Perry C, Casey MA. Factors influencing food choices of adolescents: Findings from focus-group discussions with adolescents. J Am Diet Assoc. 1999;99(8):929-937.

58. Das JK, Salam RA, Thornburg KL, Prentice AM, Campisi S, Lassi ZS, et al. Nutrition in adolescents: Physiology, metabolism, and nutritional needs. Ann N Y Acad Sci. 2017;1393(1):21-33.

59. Patton GC, Neufeld LM, Dogra S, Frongillo EA, Hargreaves D, He S, et al. Nourishing our future: The Lancet series on adolescent nutrition. Lancet. 2022;399(10320):123-125.

60. Lassi ZS, Moin A, Das JK, Salam RA, Bhutta ZA. Systematic review on evidence-based adolescent nutrition interventions. Ann N Y Acad Sci. 2017;1393(1):34-50.

61. Salam RA, Hooda M, Das JK, Arshad A, Lassi ZS, Middleton P, et al. Interventions to improve adolescent nutrition: A systematic review and meta-analysis. J Adol Health. 2016;59(4):S29-S39.

62. Warburton DE, Nicol CW, Bredin SS. Health benefits of physical activity: The evidence. CMAJ. 2006;174(6):801-809.

63. Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. Int J Behav Nutr Phys Act. 2010;7(1):40.

64. Shilton T, Bauman A, Beger B, Chalkley A, Champagne B, Elings-Pers M, et al. More people, more active, more often for heart health – taking action on physical activity. Glob Heart. 2024;3(19):42.

65. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT. Effect of physical inactivity on major non-communicable diseases worldwide: An analysis of burden of disease and life expectancy. Lancet. 2012;380(9838):219-229.

66. Kohl HW 3rd, Craig CL, Lambert EV, Inoue S, Alkandari JR, Leetongin G, et al. The pandemic of physical inactivity: Global action for public health. Lancet. 2012;380(9838):294-305.

67. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med. 2020;54(24):1451-1462.

68. Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U. Global physical activity levels: Surveillance progress, pitfalls, and prospects. Lancet. 2012;380(9838):247-257.

69. Guthold R, Stevens GA, Riley LM, Bull FC. Global trends in insufficient physical activity among adolescents: A pooled analysis of 298 population-based surveys with 1.6 million participants. Lancet Child Adolesc Health. 2020;4(1):23-35.

70. Knuth AG, Bacchieri G, Victora CG, Hallal PC. Changes in physical activity among Brazilian adults over a 5-year period. J Epidemiol Community Health. 2010;64(7):591-595.

71. Dumith SC, Gigante DP, Domingues MR, Kohl HW 3rd. Physical activity change during adolescence: A systematic review and a pooled analysis. Int J Epidemiol. 2011;40(3):685-698.

72. Marques A, Henriques-Neto D, Peralta M, Martins J, Demetriou Y, Schönbach DMI, et al. Prevalence of physical activity among adolescents from 105 low, middle, and high-income countries. Int J Environ Res Public Health. 2020;17(9)3145.

73. Telama R. Tracking of physical activity from childhood to adulthood: A review. Obesity Facts. 2009;2(3):187-195.

74. Carson V, Hunter S, Kuzik N, Gray CE, Poitras VJ, Chaput J-P, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth: An update. Appl Physiol Nutr Metab. 2016;41(6 (Suppl.3)):S240-S265.

75. Kandola A, Lewis G, Osborn DPJ, Stubbs B, Hayes JF. Depressive symptoms and objectively measured physical activity and sedentary behaviour throughout adolescence: A prospective cohort study. Lancet Psychiatry. 2020;7(3):262-271.

76. World Health Organization. Global School-based Student Health Survey (GSHS) [Internet]. 2019. [cited 2024 Jul 2]. Available from: https://www.who.int/ncds/surveillance/gshs/en/

77. Bélanger M, Casey M, Cormier M, Laflamme Filion A, Martin G, Aubut S, et al. Maintenance and decline of physical activity during adolescence: Insights from a qualitative study. Int J Behav Nutr Phys Act. 2011;8(1):117.

78. Ahmad N, Asim, HH, Juatan, N, Hipni, NE, Ithnain, N, Ahmad Sanusi, NH, et al. Contributing factors to decline in physical activity among adolescents: A scoping review. MJSSH. 2021;6(9):447-463.

79. Dagkas S, Stathi A. Exploring social and environmental factors affecting adolescents' participation in physical activity. Eur Phys Educ Rev. 2007;13(3):369-384.

80. van Sluijs EMF, Ekelund U, Crochemore-Silva I, Guthold R, Ha A, Lubans D, et al. Physical activity behaviours in adolescence: Current evidence and opportunities for intervention. Lancet. 2021;398(10298):429-442.

81. van Sluijs EMF, McMinn AM, Griffin SJ. Effectiveness of interventions to promote physical activity in children and adolescents: Systematic review of controlled trials. BMJ. 2007;335(7622):703.

82. Love R, Adams J, van Sluijs EMF. Are school-based physical activity interventions effective and equitable? A meta-analysis of cluster randomized controlled trials with accelerometer-assessed activity. Obesity Reviews. 2019;20(6):859-870.

83. Cassar S, Salmon J, Timperio A, Naylor P-J, van Nassau F, Contardo Ayala AM, et al. Adoption, implementation and sustainability of school-based physical activity and sedentary behaviour interventions in real-world settings: A systematic review. Int J Behav Nutr Phys Act. 2019;16(1):120.

84. Sutherland RL, Campbell EM, Lubans DR, Morgan PJ, Nathan NK, Wolfenden L, et al. The physical activity 4 everyone cluster randomized trial: 2-year outcomes of a school physical activity intervention among adolescents. Am J Prev Med. 2016;51(2):195-205.

85. Shin Y, Kim SK, Lee M. Mobile phone interventions to improve adolescents' physical health: A systematic review and meta-analysis. Public Health Nurs. 2019;36(6):787-799.

86. Champion KE, Parmenter B, McGowan C, Spring B, Wafford QE, Gardner LA, et al. Effectiveness of school-based eHealth interventions to prevent multiple lifestyle risk behaviours among adolescents: A systematic review and meta-analysis. Lancet Digit Health. 2019;1(5):e206-e221.

87. Spring B, Moller AC, Coons MJ. Multiple health behaviours: Overview and implications. J Public Health. 2012;34(suppl_1):i3-i10.

88. Gardner LA, Champion KE, Parmenter B, Grummitt L, Chapman C, Sunderland M, et al. Clustering of six key risk behaviors for chronic disease among adolescent females. Int J Environ Res Public Health. 2020;17(19):7211.

89. Champion KE, Mather M, Spring B, Kay-Lambkin F, Teesson M, Newton NC. Clustering of multiple risk behaviors among a sample of 18-year-old Australians and associations with mental health outcomes: A latent class analysis. Front Public Health. 2018;6:135.

90. Kessler RC, Angermeyer M, Anthony JC, R DEG, Demyttenaere K, Gasquet I, et al. Lifetime prevalence and age-of-onset distributions of mental disorders in the World Health Organization's World Mental Health Survey Initiative. World Psychiatry. 2007;6(3):168-176.

91. O'Neil A, Quirk SE, Housden S, Brennan SL, Williams LJ, Pasco JA, et al. Relationship between diet and mental health in children and adolescents: A systematic review. Am J Public Health. 2014;104(10):e31-42.

92. Bell SL, Audrey S, Gunnell D, Cooper A, Campbell R. The relationship between physical activity, mental wellbeing and symptoms of mental health disorder in adolescents: A cohort study. Int J Behav Nutr Phys Act. 2019;16(1):138.

93. Cadenas-Sanchez C, Mena-Molina A, Torres-Lopez LV, Migueles JH, Rodriguez-Ayllon M, Lubans DR, et al. Healthier minds in fitter bodies: A systematic review and meta-analysis of the association between physical fitness and mental health in youth. Sports Med. 2021;51(12):2571-2605.

94. Rodriguez-Ayllon M, Cadenas-Sánchez C, Estévez-López F, Muñoz NE, Mora-Gonzalez J, Migueles JH, et al. Role of physical activity and sedentary behavior in the mental health of preschoolers, children and adolescents: A systematic review and meta-analysis. Sports Med. 2019;49(9):1383-1410.

95. Santos RMS, Mendes CG, Sen Bressani GY, de Alcantara Ventura S, de Almeida Nogueira YJ, de Miranda DM, et al. The associations between screen time and mental health in adolescents: A systematic review. BMC Psychol. 2023;11(1):127.

96. Sampasa-Kanyinga H, Colman I, Goldfield GS, Janssen I, Wang J, Podinic I, et al. Combinations of physical activity, sedentary time, and sleep duration and their associations with depressive symptoms and other mental health problems in children and adolescents: a systematic review. Int J Behav Nutr Phys Act. 2020;17(1):72.

97. Lima F, Sims S, O'Donnell M. Harmful drinking is associated with mental health conditions and other risk behaviours in Australian young people. Aust N Z J Public Health. 2020;44(3):201-207.

98. Lawrence D, Johnson SE, Mitrou F, Lawn S, Sawyer M. Tobacco smoking and mental disorders in Australian adolescents. Aust N Z J Psychiatry. 2022;56(2):164-177.

99. Becker TD, Arnold MK, Ro V, Martin L, Rice TR. Systematic review of electronic cigarette use (vaping) and mental health comorbidity among adolescents and young adults. Nicotine Tob Res. 2020;23(3):415-425.

100. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: A systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2014;384(9945):766-781.

101. Zhang X, Liu J, Ni Y, Yi C, Fang Y, Ning Q, et al. Global prevalence of overweight and obesity in children and adolescents: A systematic review and meta-analysis. JAMA Pediatr. 2024.

102. Fan H, Zhang X. Recent trends in overweight and obesity in adolescents aged 12 to 15 years across 21 countries. Pediatr Obes. 2022;17(1):e12839.

103. Kiess W, Galler A, Reich A, Müller G, Kapellen T, Deutscher J, et al. Clinical aspects of obesity in childhood and adolescence. Obes Rev. 2001;2(1):29-36.

104. The NS, Suchindran C, North KE, Popkin BM, Gordon-Larsen P. Association of adolescent obesity with risk of severe obesity in adulthood. JAMA. 2010;304(18):2042-2047.

105. Pinhas-Hamiel O, Dolan LM, Daniels SR, Standiford D, Khoury PR, Zeitler P. Increased incidence of non-insulin-dependent diabetes mellitus among adolescents. J Pediatr. 1996;128(5 Pt 1):608-615.

106. Weiss R, Dziura J, Burgert TS, Tamborlane WV, Taksali SE, Yeckel CW, et al. Obesity and the metabolic syndrome in children and adolescents. N Engl J Med. 2004;350(23):2362-2374.

107. Lauer RM, Lee J, Clarke WR. Factors affecting the relationship between childhood and adult cholesterol levels: the Muscatine Study. Pediatrics. 1988;82(3):309-318.

108. Freedman DS, Khan LK, Dietz WH, Srinivasan SR, Berenson GS. Relationship of childhood obesity to coronary heart disease risk factors in adulthood: the Bogalusa Heart Study. Pediatrics. 2001;108(3):712-718.

109. Pont SJ, Puhl R, Cook SR, Slusser W. Stigma experienced by children and adolescents with obesity. Pediatrics. 2017;140(6);e20173034.

110. Puhl R, Suh Y. Health consequences of weight stigma: Implications for obesity prevention and treatment. Curr Obes Rep. 2015;4(2):182-190.

111. Flodgren GM, Helleve A, Lobstein T, Rutter H, Klepp K-I. Primary prevention of overweight and obesity in adolescents: An overview of systematic reviews. Obes Rev. 2020;21(11):e13102.

112. Shay CM, Ning H, Daniels SR, Rooks CR, Gidding SS, Lloyd-Jones DM. Status of cardiovascular health in US adolescents. Circulation. 2013;127(13):1369-1376.

113. Aatola H, Hutri-Kähönen N, Juonala M, Laitinen TT, Pahkala K, Mikkilä V, et al. Prospective relationship of change in ideal cardiovascular health status and arterial stiffness: The Cardiovascular Risk in Young Finns Study. J Am Heart Assoc. 2014;3(2):e000532.

114. Raitakari OT, Juonala M, Kähönen M, Taittonen L, Laitinen T, Mäki-Torkko N, et al. Cardiovascular risk factors in childhood and carotid artery intima-media thickness in adulthood: The Cardiovascular Risk in Young Finns Study. JAMA. 2003;290(17):2277-2283.

115. Laitinen TT, Pahkala K, Magnussen CG, Viikari JSA, Oikonen M, Taittonen L, et al. Ideal cardiovascular health in childhood and cardiometabolic outcomes in adulthood. Circulation. 2012;125(16):1971-1978.

116. World Health Organization. Adolescent mental health [Internet]. 2021. cited 2022 Jul 13]. Available from: https://www.who.int/news-room/fact-sheets/detail/adolescent-mental-health#:~:text=Globally%2C%20one%20in%20seven%2010,illness%20and%20disability%20among%20adolescents

117. Australian Institute of Health and Welfare. Australia's youth: Mental illness [Internet]. 2021. [cited 2022 Jul 13]. Available from: https://www.aihw.gov.au/reports/children-youth/mental-illness

118. Headspace. Insights: Youth mental health and wellbeing over time. 2020. Available from: https://headspace.org.au/assets/Uploads/Insights-youth-mental-health-and-wellbeing-over-time-headspace-National-Youth-Mental-Health-Survey-2020.pdf

119. Keles B, McCrae N, Grealish A. A systematic review: The influence of social media on depression, anxiety and psychological distress in adolescents. Int J Adolesc Youth. 2020;25(1):79-93.

120. Golberstein E, Gonzales G, Meara E. How do economic downturns affect the mental health of children? Evidence from the National Health Interview Survey. Health Econ. 2019;28(8):955-970.

121. Sinha GR, Viswanathan M, Larrison CR. Student loan debt and mental health: A comprehensive review of scholarly literature from 1900 to 2019. J Evid-Based Soc Work. 2024;21(3):363-393.

122. Sciberras E, Fernando JW. Climate change-related worry among Australian adolescents: An eight-year longitudinal study. Child Adolesc Ment Health. 2022;27(1):22-29.

123. Carney R, Imran S, Law H, Firth J, Parker S. Physical health interventions on adolescent mental health inpatient units: A systematic review and call to action. Early Interv Psychiatry. 2021;15(3):439-448.

124. Gee B, Orchard F, Clarke E, Joy A, Clarke T, Reynolds S. The effect of non-pharmacological sleep interventions on depression symptoms: A meta-analysis of randomised controlled trials. Sleep Med Rev. 2019;43:118-128.

125. Qureshi F, Guimond AJ, Tsao E, Delaney S, Boehm JK, Kubzansky LD. Adolescent psychological assets and cardiometabolic health maintenance in adulthood: Implications for health equity. J Am Heart Assoc. 2023;12(2):e026173.

126. Qureshi F, Guimond A-J, Delaney S, Boehm JK, Kubzansky LD. Who benefits and how: Five dimensions of adolescent psychological well-being and their relative impact on cardiometabolic health in adulthood. J Adoles Health. 2024;75(1):85-93.

127. Australian Government Department of Health. National action plan for the health of children and young people 2020–2030. Canberra, Australia; 2019. Available from:

https://www.health.gov.au/sites/default/files/documents/2021/04/national-action-plan-for-the-health-of-children-and-young-people-2020-2030-national-action-plan-for-the-health-of-children-and-young-people-2020-2030.pdf

128. Australian Government Department of Health. National preventive health strategy 2021–2030. Canberra, Australia; 2021. Available from: https://www.health.gov.au/sites/default/files/documents/2021/12/national-preventive-health-strategy-2021-2030_1.pdf

129. Howse E, Crosland, P, Rychetnik, L, Wilson, A. The value of prevention: An Evidence Review. 2021. Available from: https://preventioncentre.org.au/wp-content/uploads/2021/10/The-value-of-prevention-Evidence-Review-March-2021.pdf

130. Australian Institute of Health and Welfare. Health expenditure Australia 2018-19. Canberra, Australia; 2020. Available from: https://www.aihw.gov.au/getmedia/a5cfb53c-a22f-407b-8c6f-3820544cb900/aihw-hwe-80.pdf?v=20230605180154&inline=true

131. Australian Institute of Health and Welfare. Health system spending per case of disease and for certain risk factors. Canberra, Australia; 2022. Available from: https://www.aihw.gov.au/getmedia/e3bcf5bf-06f2-4d66-a81c-accef0ff08d6/health-system-spending-per-case-of-disease-and-for-certain-risk-factors.pdf?v=20240410151827&inline=true

132. Partridge SR, Reece L, Sim KA, Todd A, Jia SS, Raeside R, et al. An analysis of current obesity strategies for adolescents in NSW against best practice recommendations: Implications for researchers, policymakers and practitioners. Health Promot J Austr. 2022;34(2):390-397.

133. Kabir A, Karim MN, Islam RM, Romero L, Billah B. Health system readiness for non-communicable diseases at the primary care level: A systematic review. BMJ Open. 2022;12(2):e060387.

134. Fisher M, Freeman T, Mackean T, Friel S, Baum F. Universal health coverage for non-communicable diseases and health equity: Lessons from Australian primary healthcare. Int J Health Policy Manag. 2022;11(5):690-700.

135. Khatri RB, Assefa Y. Drivers of the Australian health system towards health care for all: A scoping review and qualitative synthesis. BioMed Res Int. 2023;2023(1):6648138.

136. Tabrizi JS, Doshmangir L, Khoshmaram N, Shakibazadeh E, Abdolahi HM, Khabiri R. Key factors affecting health promoting behaviors among adolescents: a scoping review. BMC Health Serv. Res. 2024; 24:58.

137. Rose T, Barker M, Jacob CM, Morrison L, Lawrence W, Strömmer S, et al. A Systematic Review of Digital Interventions for Improving the Diet and Physical Activity Behaviors of Adolescents. J Adolesc Health. 2017; 61(6):669-677.

138. Robinson M, Smith JA. The lazy language of 'lifestyles'. Health Promot J Austr. 2023;34(1):3-5.

CHAPTER ONE: Introduction (Part 2)

Preface to the Chapter

This chapter (Chapter One, Part 2) presents a state-of-the-art review synthesizing the current literature on adolescent health promotion in the digital era, thereby addressing Aim 1 of this thesis. The manuscript that forms this chapter has been formatted for *Health Promotion International* (submitted 19th June 2024, resubmitted with corrections following reviewer comments 24th July 2024 and 5th September 2024), and accepted for publication (2nd November 2024). Included Tables and Figures are provided in the manuscript as per journal requirements. Authors contributions to this paper are outlined in the authorship attribution statement. Chapter One was disseminated in the following ways:

Peer reviewed manuscript (accepted for publication)

Raeside R. Advancing adolescent health promotion in the digital era. *Health Promotion International* 2024; accepted 2nd November 2024.

Author attribution statement

This statement is to stipulate the contribution of Rebecca Raeside in the preparation and submission of the following manuscript: Advancing adolescent health promotion in the digital era. The convention is that the author with the principal contribution to the study is the first author.

Rebecca Raeside, during her PhD candidature, conducted the literature review, drafted the manuscript and subsequent revisions and coordinating submission for publication.

The individual roles of co-authors are listed below:

TASK	ROLE OF CO-AUTHORS
CONDUCTED LITERATURE REVIEW	RR
DRAFTING MANUSCRIPT	RR
MANUSCRIPT SUBMISSION	RR

Rebecca Raeside 26 Sept 2024

As supervisor for the candidature upon which this thesis is based, I can confirm that the author attribution statement above is correct.

Dr Stephanie Partridge 26 Sept 2024

Advancing adolescent health promotion in the digital era

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Abstract:

Adolescents globally are calling for high-quality digital services to support and improve their health and wellbeing. Digital technologies are playing an increasing role in healthcare and whilst today's adolescents have been exposed to digital media since birth, there are unique challenges to their use which must be considered. This review aims to synthesize the literature on adolescent health promotion in the digital era. It provides evidence from adolescent perspectives and identifies that community-based and 'digital only' settings hold scope for further research to advance the field. The article recommends that when working with adolescents to develop digital health promotion tools, we should look to use youth engagement frameworks which are relevant to their context. Secondly, it demands stronger governance over digital media to protect adolescents, whilst allowing safe digital access. Finally, it demonstrates how listening to adolescents may help to address the emerging digital determinants of health and avoid exacerbating health disparities. Adolescents are powerful advocates to make global change. Stakeholders across research, policy and practice should examine how they incorporate adolescent voices to drive change in health promotion in the digital era.

Keywords:

Adolescents; digital health; health promotion; determinants of health; youth engagement; risk factors

Contribution to Health Promotion Statement:

- Today's generation of adolescents are the largest generation in history and are calling for high-quality digital health and wellbeing services.
- Digital technologies may enable individuals to improve their health. However, it is essential to avoid exacerbating health disparities.

- This review synthesizes literature on adolescent health promotion in the digital era, incorporating the current evidence within various settings, adolescents perspectives towards digital health promotion and the impact of the digital determinants of health.
- Three key recommendations are provided: Use of relevant youth engagement frameworks, stronger governance of digital media and addressing the digital determinants of health.

There are 1.8 billion adolescents globally, which is more than any other time in history (Partnership for Maternal, Newborn and Child Health [PMNCH], 2023). Emerging definitions of adolescence consider those between 10-24 years old, which corresponds more closely with both adolescent growth and the shift in social roles during this life stage (Sawyer et al., 2018). The adolescents of today are powerful advocates and leaders within their communities, with the potential to make substantial changes to our world. The Agenda for Action for Adolescents, led by the PMNCH and co-developed with adolescents highlights seven priorities for urgent action (PMNCH 2023), one of which is to provide affordable, high-quality adolescent health and wellbeing services including digital services. To address this priority, we must examine the current state of adolescent health promotion in the digital era, and identify key areas for action within research, policy, and practice.

Developments in digital health promotion

Digital technologies have become entwined in the lives of people globally, including playing an increasing role in their healthcare (Miller and West, 2009). This comes with the opportunity to use digital technologies to provide access to information and services, which were previously non-existent – including in health promotion (Nutbeam et al., 2021). Digital health promotion is defined as the applications of digital technologies to enable people to increase control over, and to improve, their health (Koh et al., 2021; World Health Organization, 2024). Improving technologies, greater connectivity, and adoption of smartphones and wearable devices over time provides further potential for using digital technologies for health promotion (Koh et al., 2021). Not all countries globally have adequate healthcare coverage to provide access to health promotion information (World Health Organization, 2023), and digital technologies can be used to extend coverage and provide access. In addition, the COVID-19 pandemic accelerated the integration of digital health services into usual care (Mosnaim et al., 2020; Anthony, 2021; Dettori and Castiglia, 2022) and changed the landscape of healthcare. Digital health is here to stay, and it is vital to

identify ways we can use technology to enable individuals to increase control over, and improve, their health.

However, many digital health initiatives focus only on individual responsibility for improving health behaviours, ignoring upstream contributors which contribute to health inequalities (Williams and Fullagar, 2019). It is recognized that the ability to improve health behaviours will be more impactful in a system which also supports them, requiring multi-sector collaboration to work towards a healthy and equitable future (Sims and Aboelata, 2019). Previous work has suggested that the digital domain is a “super” social determinant of health (Hanebutt, 2023), as the gap in digital literacy and access between historically marginalized groups and others compounds existing health disparities. However, more recent literature discusses how the design, implementation and use of technology interact with the social determinants of health to influence health outcomes – such interactions are defined as the digital determinants of health (Chidambaram et al., 2024). The digital determinants of health refers to the technological factors that are incorporated to provide affordable, accessible and quality care to consumers enhancing their healthcare engagement and experience (Chidambaram et al., 2024), considering both the adoption of digital tools and health equity. It is vital that these determinants are considered to achieve health promotion through digital technologies.

Adolescents and digital health

Adolescence, 10-24-years, is a life stage of biological, emotional, and social development (Laski, 2015). It is widely recognized that specific attention should be given to adolescent health, separate to children or adults (World Health Organization, 2014). Adolescence is often regarded as the ‘second window for opportunity’ (UNICEF Office of Research – Innocenti, 2017) where influence on brain development can be achieved through the

experiences and environments to which they are exposed. Therefore, an opportunity exists to develop interventions which aim to improve adolescent health and wellbeing. Health behaviours including diet, physical activity, tobacco, and alcohol use, often begin within adolescence. These established health behaviours often continue into adulthood to influence morbidity and mortality throughout life (Viner and Macfarlane, 2005). In the last 20 years, there have been limited changes to the way preventive health care has been delivered to adolescents (Schor, 2024). However, there are emerging challenges which adolescents face to maintaining healthy behaviours, including climate change, digital technologies, social media and the commercial determinants of health (The Lancet Public, 2024). Though adolescence is a window for opportunity it is also a period of vulnerability due to neural plasticity, which may have lasting effects on adolescent development (DAHL, 2004). In particular, the commercial determinants of health, defined as the systems, practices and pathways through which commercial actors drive health and equity (Gilmore et al., 2023), have a substantial impact on adolescent health and wellbeing (Pitt et al., 2024). Commercial actors are using traditional and contemporary marketing strategies to promote harmful products to adolescents (Montgomery and Chester, 2009; Soraghan et al., 2023). Given that adolescence is a period of both opportunity and vulnerability, there is a specific need for health promotion during adolescence in acceptable and engaging formats.

Today's adolescents are digital natives, and their lives are intertwined with technology from birth (Lusk, 2010). Though there are many benefits of digital media use (learning, exposure to new knowledge, increased social support), there are also risks including negative effects on attention, exposure to misinformation and risks to privacy and confidentiality (Reid Chassiakos et al., 2016). Adolescents are typically the highest users of digital media, though access can vary in different parts of the world (Holly et al., 2023), and they use digital technologies in various ways to obtain health information. Research shows that they have been doing this for more than 20 years. A study by Skinner and colleagues in 2003 found

that adolescents were using the internet to seek health-related information and acknowledged that this brings novel challenges for health professionals (Skinner et al., 2003). Over time, the ways adolescents seek health information has evolved. In 2010, Ito and Brown found that newer forms of digital media (e.g. social media, smart phones), were more attractive to adolescents for health information since they are more interactive and mobile (Ito and Brown, 2010). More recent studies have shown that adolescents are changing their behaviour based on information found online (Blázquez Barba et al., 2018,; Raeside et al., 2022), yet the content that they are viewing has limited objectivity and transparency (Armstrong et al., 2021). Given that adolescents are digital natives and are seeking health information online, there are opportunities present to leverage digital technologies for health promotion among this age group.

Studies have been conducted to elucidate the effectiveness of digital interventions on improving health behaviours among adolescents. Rose and colleagues demonstrated that digital interventions to improve physical activity and diet among adolescents were effective in causing behaviour change, yet longer follow-ups were needed to determine whether behaviour change was sustained (Rose et al., 2017). Another systematic review confirmed these findings among web-based interventions for health behaviour change among adolescents (de Sousa et al., 2022). As the variety of digital settings grow, there is a need to evaluate emerging digital platforms. In addition, there has also been promising research demonstrating the benefits of digital interventions for mental health promotion among adolescents (Wright et al., 2023), and that digital interventions targeting preventive health behaviours have small yet positive effects on mental health and wellbeing outcomes (Raeside et al., 2023, Smout et al., 2024). Therefore, digital settings show a great deal of promise in delivering holistic health promotion information to adolescents. Yet, there are challenges which must be considered.

The following article aims to synthesize the literature on adolescent health promotion in the digital era. Four main areas are considered: (i) current settings for adolescent digital health promotion, (ii) adolescents perspectives towards digital health promotion, (iii) the relationship between the digital determinants of health and adolescent digital health promotion and (iv) areas for action in research, policy and practice.

Current settings for adolescent digital health promotion

Digital health promotion for adolescents can occur across settings including ‘digital only’, school-based, primary care, and community-based. A review by Stark and colleagues examining digital health promotion in different settings found that it is most commonly occurring in schools, communities, and ‘digital only’ settings (Stark et al., 2022). However, most of the research has been conducted in high-income countries. A recent review of digital health promotion for children and adolescents found that 82% of the included studies were conducted in high-income countries, and a larger focus is needed on research and implementation of digital health promotion for adolescents in low and middle-income countries (LMICs) (Oh et al., 2022), so that it is not only coming from a Western lens. Ferretti and colleagues explored some of the gaps and provide several important factors which must be addressed in LMICs including increasing digital access and literacy, involving adolescents in co-design, ensuring safety and monitoring of digital tools and improving technology governance (Ferretti et al., 2023b). ‘Digital only’ settings (e.g. mobile devices, web-based programs, social media, apps, telemonitoring devices) hold an important role in health promotion to adolescents as they can be delivered at scale. Though all examples described below are delivered in digital settings, some are also based within a setting which is physical. Below, we discuss the current evidence for digital health promotion in various settings.

School-based settings are important for digital health promotion amongst adolescents, given that they can reach large populations and have potential to be scaled meet the needs of adolescents. In fact, most research on digital health promotion has occurred in schools (Oh et al., 2022). However, it must be considered whether this is an effective setting for digital health promotion. Digital health promotion programs may be used within the school environment when technology is available for use (e.g. Wi-Fi), yet adolescents may not be willing to use their own mobile data for access if no connectivity is available (Kennedy et al., 2018). A review by Champion and colleagues showed promise for school-based e-health interventions to improve lifestyle health behaviours including physical activity, fruit and vegetable intake and screen time. Yet longer follow ups were needed to determine whether the behaviour change was sustained beyond the intervention period (Champion et al., 2019). In addition, important conditions have been identified to ensure effective implementation of digital health promotion programs in schools. These include that the program becomes a tool of choice in the school and links to existing school programs, that resources are invested to ensure uptake, that it is user-friendly, and that the platform engages participation of all (Dagenais et al., 2022).

Primary care - though not identified as one of the most common settings for digital health promotion - should be considered. In 2000, no studies on physical activity and nutrition interventions for adolescents within primary care were identified, digital or otherwise (Sallis et al., 2000). Studies among adults had previously shown promise, therefore this study concluded that further research to demonstrate effectiveness among adolescents was warranted. Twenty years on, considerable research has occurred demonstrating promise for adolescent digital health promotion within primary care. Yet unique challenges of technology are highlighted including the disconnect between digital tools and clinical care, privacy and security concerns of adolescents and the value of digital health tools (Wong et al., 2020). In addition, ongoing issues with access to primary care services exist for adolescents (Sanci et

al., 2005; Kang, 2018), especially those from minority groups (e.g. Indigenous populations) (Harfield et al., 2024). Adolescents desire to use technology with their health providers to have questions answered outside of visits, have greater access to providers as a method of building rapport, and for sharing data regarding their health behaviours between visits (Radovic et al., 2018). Effective policies and service planning are needed in collaboration with adolescents to ensure that digital solutions can be incorporated to deliver digital health promotion within primary care.

Community-based has many meanings with community acting as a setting, target, agent or resource (McLeroy et al., 2003). For this review, we focus on the community as a setting. Community-based approaches are important in digital health promotion as they can enable access to groups which may be particularly difficult to reach e.g. those who are socially disadvantaged or marginalized (Koh et al., 2021). There is limited research specific to adolescents in this setting. Digital formats are found to be appropriate for community health promotion when anonymity and flexibility are considered (Schroeer et al., 2021). For adolescents, this may be particularly beneficial for community-based peer support health promotion programs. Rose-Clarke and colleagues demonstrated that community-based, peer-facilitated interventions in LMICs are promising for improving adolescent health outcomes (e.g. improving mental health and reducing substance use and violence) (Rose-Clarke et al., 2019). No similar studies could be found in high-income countries. Hence, there is scope to focus research efforts on community-based digital health promotion programs. Examples of interventions in school-based, primary care, community and ‘digital only’ settings are described below in Table 1.

Table 1: Examples of digital health promotion interventions for adolescents in various settings

Setting	Description
School-based[a]	Country: 5 European Countries (Austria, Germany, Greece, Sweden, Belgium) Intervention: Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA). Computer-tailored program consisting of: (a) an introduction page; (b) a diagnostic tool; (c) advice Students received tailored feedback about their attitudes, self-efficacy, social support, knowledge, perceived benefits, and barriers related to their physical activity in the final part of the advice. Setting role: Intervention is delivered during school hours and guided by teachers Duration: 1-month Ages: 12-17 years old
Primary Care[b]	Country: USA Intervention: Electronic health risk behaviour screening with integrated feedback Setting role: Intervention is delivered during primary care visit Duration: 6-months Ages: 13-18 years old
Community-based[c]	Country: USA Intervention: Text messaging intervention to improve fruit and vegetable and healthy beverage intake in rural adolescents Setting role: Intervention is delivered to rural dwelling adolescents only Duration: 8 weeks Ages: High school students
'Digital only'[d]	Country: Australia Intervention: Text message intervention to improve body mass index and lifestyle outcomes in adolescents who are above a healthy weight Setting role: Intervention is delivered via digital setting with no restrictions on location (other than within 1 country) Duration: 6-months Ages: 13-18 years old

[a] De Bourdeaudhuij et al. (2010).

[b] Richardson et al. (2021).

[c] Gustafson et al. (2019)

d Partridge et al. (2020).

Adolescents' perspectives towards digital health promotion

While it is well-known that adolescents frequently use digital media, it is crucial to understand their acceptance of digital platforms for receiving health promotion information. Studies have been conducted in high income countries to understand how adolescents are using technology to support their health. A study conducted in the USA found that adolescents are using technology to gather information, share their experiences, view others experiences and track behaviours and health goals (Radovic et al., 2018). An Australian study found that 78% of adolescents were using websites and 77% were using social media for seeking health promotion information. However, most participants found these only somewhat helpful (Armstrong et al., 2021). Adolescents also report using websites and social media differently for accessing health promotion information. For websites, they actively search for information whereas on social media, they passively receive information presented to them (Raeside et al., 2022). Adolescents also desired health promotion information to be well-presented, credible, and relevant to them (Raeside et al., 2022). Another study which asked participants about social media specifically, had similar findings where adolescents desired information that is reliable, attractive, and tailored to meet their needs (Plaisime et al., 2020). Together, findings demonstrate that adolescents are using digital media to obtain health promotion information and that they have specific requirements which must addressed for such information to be acceptable to them.

Ferretti and colleagues were the first to synthesize all studies which gather youth perspectives on digital health promotion. Adolescents described features which appealed to them including the quality of the user interface, a supplement to their personal efforts to maintain good health, informative and tailored content, sense of community, effective behaviour change, and privacy and confidentiality (Ferretti et al., 2023a). Drawbacks to the use of digital health promotion tools were also raised, including friction with user experience,

a lack of personalisation, privacy risks, insufficient human interaction, the risk for misinformation and poor evidence of effectiveness (Ferretti et al., 2023a). These findings can also be seen in a systematic review assessing effective design features for youth engagement in games for health promotion, where Schwarz and colleagues found that adaptability to suit the user's needs, along with high-end graphics, and characters which the user can identify with were associated with higher user engagement (Schwarz et al., 2020). Adolescents have also reported that they want governments and technology companies to provide stronger regulation of online content and services which can protect them from both harm and misinformation, as well as increasing access to quality and trustworthy health information (Governing Healthy Futures Commission, 2021).

Significant investment is needed for the development of evidence-based digital health promotion interventions that are both relevant and appealing to adolescents and do not widen existing health disparities, which can be achieved through genuine youth engagement. A recent umbrella review found 99 articles describing the positive impacts of adolescent involvement in health research, which has benefits to adolescents themselves (increased knowledge and skills, personal development) and to the research (improved recruitment, data collection, and analysis). Yet the quality of the evidence remains weak due to lack of reporting and evaluation (Warraitch et al. 2024b). Challenges to involving adolescents in health research have also been identified (Warraitch et al., 2024a), many of which may be addressed by the use of youth engagement theories, guidelines or frameworks to guide adolescent involvement. Youth engagement theories, guidelines and frameworks have been used widely within the literature (Sanchez et al. 2024; Warraitch et al., 2024c), which may be classified as power, process, impact, or equity focused. Examples of each focused framework are available in Table 2. Though there are many available, they are often narrow in scope, limited to one context and may depend on available resources (Sanchez et al., 2024).

Table 2: Examples of youth engagement theories, guidelines and frameworks

Focus	Description	Example
Power-focused	Focus is on identifying, describing or explaining who has leadership or power in partnership between youth and researchers	Authentic Youth Participation[a]
Process-focused	Focus is on describing barriers, facilitators and other factors affecting youth engagement in research	Youth Agency for Social Change Model[b]
Impact-focused	Focus is on describing and conceptualizing the potential impacts of youth engagement in research	EIPARS Model[c]
Equity-focused	Focus is on identifying and proposing alternative approaches to conventional methods in research	YPAR 2.0 Model of Research Engagement[d]

[a] Hinkle et al. (2018)

[b] Suleiman et al. (2006).

[c] Norman and Skinner (2007).

[d] Akom et al. (2016).

Relationship between the digital determinants of health and adolescent digital health promotion

Though digital health promotion interventions hold promise to improve adolescent health outcomes and improve access, they also have the potential to exacerbate existing health disparities. Digital health promotion interventions typically support individuals to improve health outcomes through behaviour change (Webb et al., 2010; Lustria et al., 2013). These often require individuals to have digital technology access and high levels of digital health literacy (Busse et al., 2022). As a result, evidence suggests that digital health interventions may be less effective for historically marginalized groups (Brewer et al., 2020). This is known as the digital divide, where disparities exist between those with digital access and digital literacy, and those without (Hanebutt, 2023). Among adolescent digital health promotion interventions which are growing in popularity, most do not consider factors that affect access

and engagement (Rose et al., 2017, Raeside et al., 2023) and of those that do, few sought to implement strategies that would improve these when identified (Whitehead et al., 2024).

We can look to adolescent digital health promotion to drive change in addressing the digital determinants of health (Kickbusch and Holly, 2023). Many of the adolescent attitudes towards digital health promotion identified by Ferretti et al. (Ferretti et al., 2023a) are cross cutting with dimensions of the digital determinants of health (Chidambaram et al., 2024). For example, technology personalization is one of the digital determinants of health, also cited by adolescents to be highly appealing. Furthermore, adolescents have called for high quality, usable digital tools for health promotion, addressing further dimensions of the digital determinants of health including ease of use, usefulness, interactivity, and digital literacy. Figure 1 depicts a concept map demonstrating cross-cutting themes between adolescent attitudes towards digital health promotion and the digital determinants of health. By genuinely engaging adolescents in development of digital health promotion interventions, we can seek to create digital health promotion tools which do not widen existing health disparities.

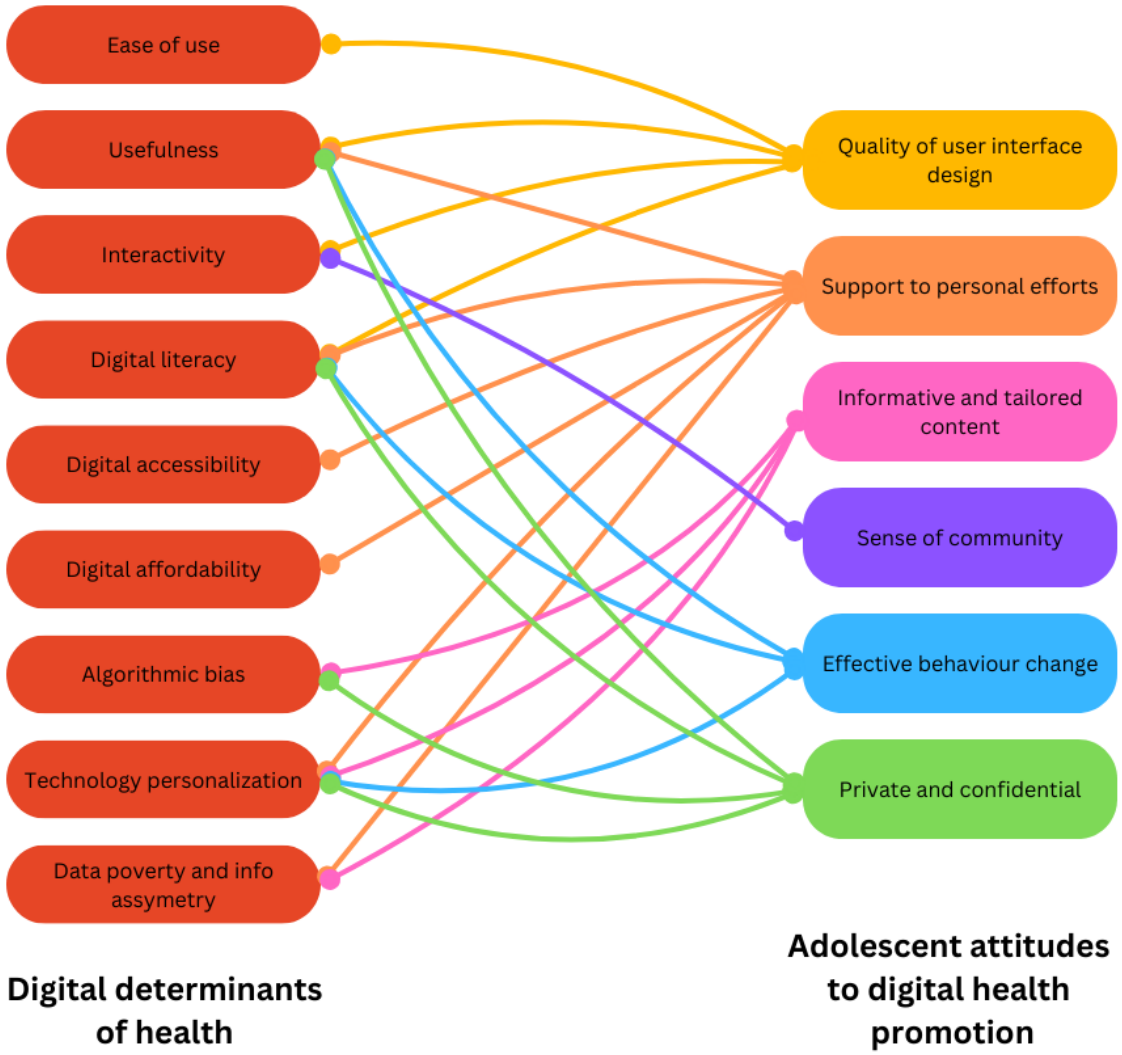

Figure 1. Concept map of digital determinants of health linked with adolescent attitudes to digital health promotion

Development of effective and equitable digital health promotion tools for adolescents cannot be achieved by youth engagement alone. Stronger governance and regulation around digital media is also crucial for addressing the digital determinants of health (Governing Healthy Futures Commission, 2021), and protecting the wellbeing of adolescents (Holly et al., 2023). Adolescents remain vulnerable as they are creating online identities whilst they continue to grow and develop offline (Israni et al., 2020). In summary, adolescents have unique views on the use of digital tools for health promotion which must be explored and adhered to when

developing tools for digital health promotion, and governments and technology companies have a crucial role to play in protecting adolescents in the digital world.

Areas for action in research, policy and practice

Digital health promotion for adolescents has strong potential for effectiveness. Yet, the need for health promotion among adolescents challenges the capacity of traditional healthcare systems and school settings. Current evidence demonstrates that there is scope for adolescent digital health promotion interventions particularly within community-based and 'digital only' settings. However, developing and implementing effective digital health promotion interventions for adolescents requires new approaches which engage adolescents throughout the entire research process and in the development of policies to protect them in a digital world. Three key areas for action are suggested:

Use of relevant youth engagement frameworks

It is important for researchers to select theories, guidelines or frameworks which are relevant to their context. However, it is difficult to provide specific examples for each context as relevance will depend on systemic factors including time, resources, systems, and expertise within the team. Studies which synthesize theories, guidelines and frameworks (Sanchez et al., 2024; Warraitch et al., 2024c) are a good starting place for those working to engage youth. It is acknowledged that further work is needed to provide youth engagement theories, guidelines and frameworks which are comprehensive, developed with youth, and can be applied across multiple contexts. Selection and application of the most appropriate youth engagement frameworks (taking systemic factors into account) in development of digital health promotion interventions will provide valuable reporting and evaluation guidance for those in research, policy, and practice. This in turn will lead to generation of rigorous, higher quality studies that will help to drive policy action.

Stronger governance of digital media

Action is needed to strengthen governance through proactive policies from technology companies along with government-led legislation which acts to protect adolescent health and wellbeing, yet also allows them access to continue to explore the digital world safely (Roman-Urrestarazu et al., 2022). Effective legislation from governments may include regulation on the quality of health information on social media platforms, and regulation on marketing of unhealthy products. Furthermore, greater commitment from governments and educators to improve digital health literacy skills of adolescents is needed. Adolescents themselves should also be given the right to contribute to the development of these policies (United Nations, 1990), as their unique perspectives and experiences are key to shaping a digital environment which is safe, equitable and inclusive for all.

Addressing the digital determinants of health

To ensure that all digital determinants of health are addressed, it is vital to seek representation from a broad range of adolescents when engaging them to develop digital health promotion tools. Without fundamental change to address the digital domain as a "super" social determinant of health, the digital divide will only continue to be exacerbated. Frameworks have been developed to support the development of digital health tools which are equitable, and in line with the digital determinants of health across individual, interpersonal, community and societal levels (Richardson et al., 2022). Such frameworks will support those who develop digital health tools within academia and practice to ensure that they do not widen the equity gap.

Today's adolescents have the power as the largest generation in history to make substantial social and system changes to our world. The development of high-quality digital health

promotion tools that empower adolescents to improve health behaviours is within reach. Researchers, policymakers, and those in practice must look to engage adolescents to drive change. This in turn will assist in the development of digital health promotion tools which are equitable and accessible for all.

Authors Contributions

RR contributed to the conceptualization, drafting and critical revisions of the manuscript.

Acknowledgements

I would like to acknowledge my PhD supervisors Dr Stephanie Partridge and Professor Julie Redfern for their guidance and contribution to the development of this review.

Conflicts of Interest

I have no conflicts of interest to declare.

Funding

This work was supported by a NHMRC SOLVE-CHD Completion Scholarship awarded to RR.

References

Akom, A., Shah, A., Nakai, A. and Cru, T. (2016) Youth participatory action research (YPAR) 2.0: how technological innovation and digital organizing sparked a food revolution in East Oakland. *International Journal of Qualitative Studies in Education*, 29, 1287–1307.

Anthony, Jr, B. (2021) Integrating telemedicine to support digital health care for the management of COVID-19 pandemic. *International Journal of Healthcare Management*, 14, 280–289.

Armstrong, M., Halim, N. K., Raeside, R., Jia, S. S., Hyun, K., Boroumand, F. et al (2021) How helpful and what is the quality of digital sources of healthy lifestyle information used by Australian adolescents? A mixed methods study. *International Journal of Environmental Research and Public Health*, 18, 12844.

Blázquez Barba, M., Gómez Romero, D., Frontaura Fernández, I., Camacho Ojeda, A., Rodríguez Salas, F. M. and Toriz Cano, H. (2018) Use of new technologies by adolescents in the search for health information. *Atencion Primaria*, 50, 547–552.

Brewer, L. C., Fortuna, K. L., Jones, C., Walker, R., Hayes, S. N., Patten, C. A. et al (2020) Back to the future: achieving health equity through health informatics and digital health. *JMIR Mhealth Uhealth*, 8, e14512.

Busse, T. S., Nitsche, J., Kernebeck, S., Jux, C., Weitz, J., Ehlers, J. P. et al (2022) Approaches to Improvement of Digital Health Literacy (eHL) in the context of person-centered care. *International Journal of Environmental Research and Public Health*, 19, 8309.

Champion, K. E., Parmenter, B., McGowan, C., Spring, B., Wafford, Q. E., Gardner, L. A. et al; Health4Life Team. (2019) Effectiveness of school-based eHealth interventions to prevent multiple lifestyle risk behaviours among adolescents: a systematic review and meta-analysis. *Lancet Digital Health*, 1, e206–e221.

Chidambaram, S., Jain, B., Jain, U., Mwavu, R., Baru, R., Thomas, B. et al (2024) An introduction to digital determinants of health. *PLOS Digital Health* , 3, e0000346.

Dagenais, C. P., Proulx, M. P. and McSween-Cadieux, E. P. (2022) Using digital platforms in schools for prevention and health promotion: a scoping review. *Health Behavior and Policy*

Review, 9, 719–737.

Dahl, R. E. (2004) Adolescent brain development: a period of vulnerabilities and opportunities. Keynote address. *Annals of the New York Academy of Sciences*, 1021, 1–22.

De Bourdeaudhuij, I., Maes, L., De Henauw, S., De Vriendt, T., Moreno, L. A., Kersting, M. et al; HELENA Study Group. (2010) Evaluation of a computer-tailored physical activity intervention in adolescents in six European countries: the Activ-O-Meter in the HELENA intervention study. *The Journal of Adolescent Health*, 46, 458–466.

de Sousa, D., Fogel, A., Azevedo, J. and Padrão, P. (2022) The effectiveness of web-based interventions to promote health behaviour change in adolescents: a systematic review. *Nutrients*, 14, 1258.

Dettori, M. and Castiglia, P. (2022) COVID-19 and digital health: evolution, perspectives and opportunities. *International Journal of Environmental Research and Public Health*, 19, 8519.

Ferretti, A., Hubbs, S. and Vayena, E. (2023a) Global youth perspectives on digital health promotion: a scoping review. *BMC Digital Health*, 1, 25.

Ferretti, A., Vayena, E. and Blasimme, A. (2023b) Unlock digital health promotion in LMICs to benefit the youth. *PLOS Digital Health*, 2, e0000315.

Gilmore, A. B., Fabbri, A., Baum, F., Bertscher, A., Bondy, K., Chang, H. J. et al (2023) Defining and conceptualising the commercial determinants of health. *Lancet*, 401, 1194–1213.

Governing Healthy Futures Commission. (2021) Digital health futures: insights into young people's use and opinions of digital health technologies. Summary report of a 2020 U-report poll. Geneva.

Gustafson, A., Jilcott Pitts, S. B., McQuerry, K., Babtunde, O. and Mullins, J. (2019) A mentor led text-messaging intervention increases intake of fruits and vegetables and goal setting for healthier dietary consumption among rural adolescents in Kentucky and North Carolina, 2017. *Nutrients*, 11, 593.

Hanebutt, R. and Mohyuddin, H. (2023) The digital domain. *Primary Care: Clinics in Office Practice*, 50, 657–670.

Harfield, S., Purcell, T., Schioldann, E., Ward, J., Pearson, O. and Azzopardi, P. (2024) Enablers and barriers to primary health care access for Indigenous adolescents: a systematic review and meta-aggregation of studies across Australia, Canada, New Zealand, and USA. *BMC Health Services Research*, 24, 553.

Hinkle, A. J., Sands, C., Duran, N., Houser, L., Liechty, L. and Hartmann-Russell, J. (2018) How food & fitness community partnerships successfully engaged youth. *Health Promotion Practice*, 19, 34S–44S.

Holly, L., Wong, B. L. H., Kessel, R. van, Awah, I., Agrawal, A. and Ndili, N. (2023) Optimising adolescent wellbeing in a digital age. *British Medical Journal*, 380, e068279.

Israni, S. T., Matheny, M. E., Matlow, R. and Whicher, D. (2020) Equity, inclusivity, and innovative digital technologies to improve adolescent and young adult health. *Journal of Adolescent Health*, 67, S4–S6.

Ito, K. E. and Brown, J. D. (2010) To friend or not to friend: using new media for adolescent health promotion. *North Carolina Medical Journal*, 71, 367–372.

Kang M. R. F., Sanci, L., Steinbeck, K., Jan, S,, Hawke, C., Luscombe, G., Kong, M. and Usherwood, T. (2018) Access 3: young people and the health system in the digital age - final research report. Kennedy, S. G., Smith, J. J., Morgan, P. J., Peralta, L. R., Hilland, T. A., Eather, N. et al (2018) Implementing resistance training in secondary schools: a cluster randomized controlled trial. *Medicine & Science in Sports & Exercise*, 50, 62–72.

Kickbusch, I. and Holly, L. (2023) Addressing the digital determinants of health: health promotion must lead the charge. *Health Promotion International*, 38, daad059.

Koh, A., Swanepoel, D. W., Ling, A., Ho, B. L., Tan, S. Y. and Lim, J. (2021) Digital health promotion: promise and peril. *Health Promotion International*, 36, i70–i80.

Laski, L. (2015) Realising the health and wellbeing of adolescents. *British Medical Journal*, 351, h4119.

Lusk, B. (2010) Digital natives and social media behavior: an overview. *The Prevention Researcher*, 17, 3–6.

Lustria, M. L., Noar, S. M., Cortese, J., Van Stee, S. K., Glueckauf, R. L. and Lee, J. (2013) A meta-analysis of web-delivered tailored health behavior change interventions. *Journal of Health Communication*, 18, 1039–1069.

McLeroy, K. R., Norton, B. L., Kegler, M. C., Burdine, J. N. and Sumaya, C. V. (2003) Community-based interventions. *American Journal of Public Health*, 93, 529–533.

Miller, E. A. and West, D. M. (2009) Where's the revolution? Digital technology and health care in the internet age. *Journal of Health Politics, Policy and Law*, 34, 261–284.

Montgomery, K. C. and Chester, J. (2009) Interactive food and beverage marketing: targeting adolescents in the digital age. *The Journal of Adolescent Health*, 45, S18–S29.

Mosnaim, G. S., Stempel, H., Van Sickle, D. and Stempel, D. A. (2020) The adoption and implementation of digital health care in the post-COVID-19 era. *The Journal of Allergy and Clinical Immunology: In Practice*, 8, 2484–2486.

Norman, C. D. and Skinner, H. A. (2007) Engaging youth in e-health promotion: lessons learned from a decade of TeenNet research. *Adolescent Medicine: State of the Art Reviews*, 18, 357–369, xii.

Nutbeam, D., Corbin, J. H. and Lin, V. (2021) The continuing evolution of health promotion. *Health Promotion International*, 36, i1–i3.

Oh, C., Carducci, B., Vaivada, T. and Bhutta, Z. A. (2022) Digital interventions for universal health promotion in children and adolescents: a systematic review. *Pediatrics*, 149, e2021053852H.

Partridge, S. R., Raeside, R., Singleton, A. C., Hyun, K., Latham, Z., Grunseit, A. et al (2020) Text message behavioral intervention for teens on eating, physical activity and social wellbeing (TEXTBITES): protocol for a Randomized Controlled Trial. *JMIR Research Protocols*, 9, e16481.

Pitt, H., McCarthy, S. and Arnot, G. (2024) Children, young people and the commercial determinants of health. *Health Promotion International*, 39, daad185.**AQ10**

Plaisime, M., Robertson-James, C., Mejia, L., Núñez, A., Wolf, J. and Reels, S. (2020) Social media and teens: a needs assessment exploring the potential role of social media in promoting health. *Social Media ± Society*, 6, 2056305119886025.

PMNCH. (2023) *Agenda for Action for Adolescents*. Retrieved 16/11/2023, from https://www.1point8b.org/agendaforactionforadolescents

Radovic, A., McCarty, C. A., Katzman, K. and Richardson, L. P. (2018) Adolescents' perspectives on using technology for health: qualitative study. *JMIR Pediatrics and Parenting*, 1, e2.

Raeside, R., Jia, S. S., Redfern, J. and Partridge, S. R. (2022) Navigating the online world of lifestyle health information: qualitative study with adolescents. *JMIR Pediatrics and Parenting*, 5, e35165.

Raeside, R., Jia, S. S., Todd, A., Hyun, K., Singleton, A., Gardner, L. A. et al (2023) Are digital health interventions that target lifestyle risk behaviors effective for improving mental health and wellbeing in adolescents? A systematic review with meta-analyses. *Adolescent Research Review*, 9, 193–226.

Reid Chassiakos, Y., Radesky, J., Christakis, D., Moreno, M. A., Cross, C., Hill, D. et al; C. O. Communications, Media. (2016) Children and adolescents and digital media. *Pediatrics*, 138, e20162593.

Richardson, S., Lawrence, K., Schoenthaler, A. M. and Mann, D. (2022) A framework for digital health equity. *NPJ Digital Medicine*, 5, 119.

Richardson, L., Parker, E. O., Zhou, C., Kientz, J., Ozer, E. and McCarty, C. (2021) Electronic health risk behavior screening with integrated feedback among adolescents in primary care: randomized controlled trial. *Journal of Medical Internet Research*, 23, e24135.

Roman-Urrestarazu, A., Kinsey, J. and Kessel, R. van. (2022) A bill of children's digital rights is required to improve and sustain children's futures globally. *JAMA Pediatrics*, 176, 1064–1066.

Rose-Clarke, K., Bentley, A., Marston, C. and Prost, A. (2019) Peer-facilitated community-based interventions for adolescent health in low- and middle-income countries: a systematic

review. *PLoS One*, 14, e0210468.

Rose, T., Barker, M., Maria Jacob, C., Morrison, L., Lawrence, W., Strömmer, S. et al (2017) A systematic review of digital interventions for improving the diet and physical activity behaviors of adolescents. *The Journal of Adolescent Health*, 61, 669–677.

Sallis, J. F., Patrick, K., Frank, E., Pratt, M., Wechsler, H. and Galuska, D. A. (2000) Interventions in health care settings to promote healthful eating and physical activity in children and adolescents. *Preventive Medicine*, 31, S112–S120.

Sanchez, S., Thorburn, R., Rea, M., Kaufman, P., Schwartz, R., Selby, P. et al (2024) A systematic review of theories, models and frameworks used for youth engagement in health research. *Health Expectations*, 27, e13975.

Sanci, L. A., Kang, M. S. -L. and Ferguson, B. J. (2005) Improving adolescents access to primary health care. *Medical Journal of Australia*, 183, 416–417.

Sawyer, S. M., Azzopardi, P. S., Wickremarathne, D. and Patton, G. C. (2018) The age of adolescence. *The Lancet Child & Adolescent Health*, 2, 223–228.

Schor, E. L. (2024) Capitated, multisector, universal preventive health care for children and youth. *JAMA Pediatrics*, 178, 215–216.

Schroeer, C., Voss, S., Jung-Sievers, C. and Coenen, M. (2021) Digital formats for community participation in health promotion and prevention activities: a scoping review. *Frontiers in Public Health*, 9, 713159.

Schwarz, A. F., Huertas-Delgado, F. J., Cardon, G. and DeSmet, A. (2020) Design features associated with user engagement in digital games for healthy lifestyle promotion in youth: a systematic review of qualitative and quantitative studies. *Games for Health Journal*, 9, 150–163.

Sims, J. and Aboelata, M. J. (2019) A system of prevention: applying a systems approach to public health. *Health Promotion Practice*, 20, 476–482.

Skinner, H., Biscope, S., Poland, B. and Goldberg, E. (2003) How adolescents use technology for health information: implications for health professionals from focus group studies. *Journal of Medical Internet Research*, 5, e32.

Smout, S., Champion, K. E., O'Dean, S., Teesson, M., Gardner, L. A. and Newton, N. C. (2024) Anxiety, depression and distress outcomes from the Health4Life intervention for adolescent mental health: a cluster-randomized controlled trial. *Nature Mental Health*, 2, 818–827.

Soraghan, M., Abdulkareem, T. O., Jennings, B., Boateng, J. A., Chavira García, J., Chopra, V. et al (2023) Harmful marketing by commercial actors and policy ideas from youth. *Health Promotion International*, 38, daad149.

Stark, A. L., Geukes, C. and Dockweiler, C. (2022) Digital health promotion and prevention in settings: scoping review. *Journal of Medical Internet Research*, 24, e21063.

Suleiman, A. B., Soleimanpour, S. and London, J. (2006) Youth action for health through youth-led research. *Journal of Community Practice*, 14, 125–145.

The Lancet Public Health. (2024) Investing in adolescent health and wellbeing. *The Lancet Public Health*, 9, e635.

UNICEF Office of Research – Innocenti. (2017) *The Adolescent Brain: A second window of opportunity - A Compendium*. UNICEF Office of Research - Innocenti, Florence.

United Nations. (1990) Convention on the rights of the child, General Assembly resolution 44/25.

Viner, R. and Macfarlane, A. (2005) Health promotion. *British Medical Journal*, 330, 527–529.

Warraitch, A., Lee, M., Bruce, D., Curran, P., Khraisha, Q., Wacker, C. et al (2024a) An umbrella review of reviews on challenges to meaningful adolescent involvement in health research. *Health Expectations*, 27, e13980.

Warraitch, A., Wacker, C., Biju, S., Lee, M., Bruce, D., Curran, P. et al (2024b) Positive impacts of adolescent involvement in health research: an umbrella review. *Journal of Adolescent Health*, 75, 218–230.

Warraitch, A., Wacker, C., Bruce, D., Bourke, A. and Hadfield, K. (2024c) A rapid review of guidelines on the involvement of adolescents in health research. *Health Expectations*, 27, e14058.

Webb, T. L., Joseph, J., Yardley, L. and Michie, S. (2010) Using the internet to promote health behavior change: a systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. *Journal of Medical Internet Research*, 12, e4.

Whitehead, L., Robinson, S., Arabiat, D., Jenkins, M. and Morelius, E. (2024) The report of access and engagement with digital health interventions among children and young people: systematic review. *JMIR Pediatrics and Parenting*, 7, e44199.

Williams, O. and Fullagar, S. (2019) Lifestyle drift and the phenomenon of 'citizen shift' in contemporary UK health policy. *Sociology of Health and Illness*, 41, 20–35.

Wong, C. A., Madanay, F., Ozer, E. M., Harris, S. K., Moore, M., Master, S. O. et al (2020) Digital health technology to enhance adolescent and young adult clinical preventive services: affordances and challenges. *Journal of Adolescent Health*, 67, S24–S33.

World Health Organization. (2014) *Health for the World's Adolescents: A Second Chance in the Second Decade*. Department of Maternal, Newborn, Child and Adolescent Health Geneva, p.5-7.

World Health Organization. (2023) *Universal Health Coverage*. https://www.who.int/healthtopics/universal-health-coverage (last accessed 3 March 2024).

World Health Organization. (2024) *Health Promotion*. https://www.who.int/westernpacific/about/how-we-work/programmes/health-promotion (last accessed 3 March 2024).

Wright, M., Reitegger, F., Cela, H., Papst, A. and Gasteiger-Klicpera, B. (2023) Interventions with digital tools for mental health promotion among 11–18 year olds: a systematic review and meta-analysis. *Journal of Youth and Adolescence*, 52, 754–779.

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CHAPTER TWO: Are digital health interventions that target lifestyle risk behaviours effective for improving mental health and wellbeing in adolescents? A systematic review with meta-analyses

Preface to the Chapter

This chapter (Chapter Two) presents the findings of a systematic review with meta-analyses to evaluate how effective digital health interventions which target lifestyle risk behaviours are in improving mental health and wellbeing among adolescents, thereby addressing Aim 2 of this thesis. This systematic review with meta-analyses has been peer-reviewed (submitted 16th May 2023, resubmitted with corrections following reviewer comments 18th July 2023) and published (12th August 2023) in *Adolescent Research Review.* Authors contributions to this paper are outlined in the authorship attribution statement. Chapter Two was disseminated in the following ways:

Published peer reviewed manuscript

Raeside R, Jia SS, Todd A, Hyun K, Singleton A, Gardner LA, Champion KE, Redfern J, Partridge SR. Are Digital Health Interventions That Target Lifestyle Risk Behaviors Effective for Improving Mental Health and Wellbeing in Adolescents? A Systematic Review with Meta-analyses. *Adolescent Res Rev* 9, 193-226 (2023). doi: 10.1007/s40894-023-00224-w

Conference presentations

1. **Raeside R** et al (7-9/11/2022) Effectiveness of digital health interventions targeting lifestyle risk factors on improving adolescent mental health or wellbeing: a systematic review. 10-min oral. Australian Association for Adolescent Health Youth Health Conference 2022. Melbourne, Australia.
2. **Raeside R** et al (14-17/06/2023) Effectiveness of digital health interventions targeting lifestyle risk behaviours on improving adolescent mental health or wellbeing: a

systematic review with meta-analysis. 10-min oral (prize session). International Society of Behavioural Nutrition and Physical Activity Annual Meeting 2023. Uppsala, Sweden

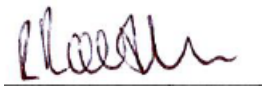
Author attribution statement

This statement is to stipulate the contribution of Rebecca Raeside in the preparation and submission of the following manuscript: Are Digital Health Interventions That Target Lifestyle Risk Behaviors Effective for Improving Mental Health and Wellbeing in Adolescents? A Systematic Review with Meta-analyses. The convention is that the author with the principal contribution to the study is the first author.

Rebecca Raeside, during her PhD candidature, developed the concept for the study, designed the study protocol, conducted database searches, screened all articles for inclusion, performed data extraction, analysed the data, interpreted the results, drafted the manuscript and subsequent revisions and coordinating submission for publication.

The individual roles of co-authors are listed below:

TASK	ROLE OF CO-AUTHORS
CONCEIVED THE RESEARCH QUESTION	RR
PROVIDED INPUT TO STUDY PROTOCOL	RR, SSJ, KH, AS, LAG, KEC, JR, SRP
CONDUCTED DATABASE SEARCHES	RR
CONDUCTED SCREENING AND CODING OF ARTICLES	RR, SSJ, AT, SRP
CONDUCTED DATA EXTRACTION	RR, SSJ, AT, SRP
CONDUCTED META-ANALYSES	RR
INTERPRETATION OF FINDINGS	RR, KH, SRP
DRAFTING MANUSCRIPT	RR
REVISION AND CRITICAL COMMENTS ON MANUSCRIPT	RR, SSJ, AT, KH, AS, LAG, KEC, JR, SRP
MANUSCRIPT SUBMISSION	RR

Rebecca Raeside  26 Sept 2024

As supervisor for the candidature upon which this thesis is based, I can confirm that the author attribution statement above is correct.

Dr Stephanie Partridge  26 Sept 2024

Adolescent Research Review
https://doi.org/10.1007/s40894-023-00224-w

Are Digital Health Interventions That Target Lifestyle Risk Behaviors Effective for Improving Mental Health and Wellbeing in Adolescents? A Systematic Review with Meta-analyses

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Received: 16 May 2023 / Accepted: 19 July 2023

Abstract
Research has established associations between poor mental health and lifestyle risk behaviors among adolescents, yet gaps exist in understanding whether digital health interventions for adolescents targeting these behaviors will improve mental health and wellbeing. This study aimed to evaluate how effective digital health interventions targeting lifestyle risk behaviors are in improving mental health/wellbeing among adolescents (10–24 years old). We also aimed to understand how effects vary by participant and intervention characteristics, and intervention adherence and engagement. Through systematic review with meta-analysis, 5229 records were identified. 17 studies were included representing 9070 participants (15.3 mean age, 1.2 SD). Interventions had small but statistically non-significant positive effects on physical and psychosocial quality of life, depressive symptoms and anxiety at follow-up compared to usual care controls. Digital health delivery methods included text messaging, mobile applications, websites and email, or a combination of these. Intervention adherence, engagement and satisfaction were measured poorly across studies. Despite small changes, potential exists for digital health interventions to improve mental health or wellbeing outcomes among adolescents due to the shared nature of risk and protective factors for mental health and chronic diseases.

Keywords Adolescent · Digital health · Risk factors · Mental health · Wellbeing · Systematic review · Meta-analysis

Introduction

Adolescence is a critical life-stage for development of physical and mental health. Health promoting behaviors need to be established and maintained to ensure good physical and mental health and wellbeing during adolescence and into adulthood (World Health Organization, 2014). However, due to an increase in unhealthy lifestyle behaviors adolescents are at risk of chronic diseases in adulthood such as cardiovascular disease (Barbaresko et al., 2018) and obesity (Farhat et al., 2010). Rates of mental health conditions among adolescents are increasing, with global estimations that 14% of 10–19-year-olds experience a mental health condition or disorder (World Health Organization, 2021) and half of all mental disorders emerge at the age of 14 (Kessler et al., 2007). Emerging research demonstrates that during the first year of the Coronavirus Disease 2019 (COVID-19) pandemic the prevalence of mental health conditions increased to 25% (Racine et al., 2021), yet whether this increased prevalence will remain and the potential long-term implications of this are still unknown. Research has established associations between poor mental health among adolescents and lifestyle risk behaviors including physical inactivity (Sampasa-Kanyinga et al., 2020), sub-optimal diet (O'Neil et al., 2014), sedentary behavior (Rodriguez-Ayllon et al., 2019), poor sleep hygiene, alcohol intake (Lima et al., 2020) and tobacco/e-cigarette smoking (Javed et al., 2022;

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Published online: 12 August 2023

Lawrence et al., 2022). There is growing evidence that interventions to improve lifestyle risk behaviors are associated with improvements in mental health and wellbeing outcomes (Dale et al., 2014), as well as physical health outcomes, such as obesity (Galani et al., 2007). Yet, most previous research was conducted in adults and only 35% of these studies were conducted in healthy populations (Dale et al., 2014). This study aims to cover existing knowledge gaps in understanding whether interventions targeting lifestyle risk behaviors will improve mental health and wellbeing among adolescents, especially in the context of digital health.

Digital health interventions are increasingly popular for achieving health objectives such as healthy lifestyle management (Chatterjee et al., 2021) and address health system shortcomings (e.g., access issues) (Kang et al., 2018). Healthcare systems need to provide preventive healthcare to adolescents in formats that are acceptable and engaging to them and can be delivered on a large scale. Additionally, given half of all mental disorders are established in adolescence but are undetected for many years (World Health Organization, 2022), digital health interventions may provide an opportunity to reach these young people. Previous systematic reviews have demonstrated that digital health school-based interventions addressing multiple lifestyle risk behaviors were effective for improving physical activity, fruit and vegetable intake and reducing screen time (Champion et al., 2019). Previous systematic reviews have also shown the effectiveness of digital health interventions for diet and physical activity behaviors (Rose et al., 2017) and supporting weight management (Kouvari et al., 2022) among adolescents. Furthermore, there is increasing research into the application of digital health interventions for prevention of mental health conditions among adolescents (Bantjes, 2022; Bergin et al., 2020; Werner-Seidler et al., 2020). However, this is the first study of its kind to specifically focus on the effectiveness of such interventions on improving mental health or wellbeing outcomes.

Current Study

Emerging evidence suggests interventions which aim to improve lifestyle risk behaviors are associated with improvements in mental health and wellbeing outcomes, and digital health interventions provide the opportunity to be delivered at scale to reach adolescents and provide healthy lifestyle management. The current study aimed to investigate the effectiveness of digital health interventions targeting key lifestyle risk behaviors (physical activity, diet, sedentary behavior, sleep, alcohol and/or smoking) on mental health or wellbeing outcomes among adolescents. A second aim is to evaluate how the effects of digital health interventions vary by participant characteristics (e.g., gender, age) intervention characteristics (e.g., delivery method, frequency, duration, type of risk behaviors) and intervention adherence and engagement.

Methods

Protocol and Registration

This systematic review was conducted and reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement guidelines (Page et al., 2021) (Supplementary File 1) and followed the predetermined methods documented in a protocol. The review was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO; Registration Number: CRD42021247738).

Eligibility Criteria

Studies were included that met the following criteria: (1) randomised controlled trials (RCTs) or cluster randomised controlled trials (cRCTs); (2) participants were adolescents 10–24 years, defined by the Lancet definition of adolescence (Kinghorn et al., 2018), all genders were included who were free from existing mental health diagnosis, not pregnant or post-partum and free of acute illness or other significant chronic disease that requires specific diet and/or physical activity management (e.g. type 1 diabetes mellitus); (3) intervention focused on one or more of the following six lifestyle risk behaviors: dietary behaviors, physical activity, sedentary behaviors, sleep, alcohol and/or tobacco; (4) an outcome of mental health or wellbeing. The list of outcomes was adapted from another systematic review (Melissa Bujtor, 2019) and included both psychological well-being (self-efficacy, self-esteem, self-image, self-concept, quality of life, health related quality of life, positive affect) and psychological ill-being outcomes (stress, anxiety, depressive symptoms, psychological distress, negative affect); (5) digital health intervention of any duration, including mobile technology (mobile phone applications, text messaging), websites, social media, smart watches, activity trackers, email and Personal Digital Assistant use; (6) A comparator group receiving standard or usual care (no intervention); (7) All settings were included including community, home or school-based and health care; (8) published in any language and; (9) studies published after 2005. The cut-off date of 2005 was selected as the current generation of adolescents ('Generation Z') appeared in the population after 1995, and the oldest of this generation were 10 years old in 1995.

Information Sources and Search Strategy

Ten major electronic databases (Pre-Medline, Medline, Cochrane, Cochrane Central Register of Controlled Trials, Embase, CINAHL, AMED, Informit, Scopus and Web of Science) were systematically searched on 25th June, 2021 and updated on August 17, 2022. The database searches were developed in conjunction with an academic librarian. Search terms included combinations, truncations and synonyms of the following (1) digital health (telehealth; eHealth, mHealth, mobile applications, text messaging, internet, social media, smartwatch, fitness tracker, personal digital assistant) (2) physical activity, diet, sedentary behavior, sleep, alcohol and/or smoking (3) mental health and wellbeing (self-esteem, self-efficacy, quality of life, anxiety, depressive symptoms, self-image, resilience, stress) and (4) adolescent. Database RCT filters were applied to maximise the results of RCTs and cRCTs and limits were set to only identify papers published from 2005 to current. The full electronic search strategy for each database is available in Supplementary File 2.

Study Selection

One author (RR) carried out all electronic database searches. Search results across databases were merged using Endnote X9 reference management software and duplicates of the same study were removed. Following merging the results in Endnote, they were then uploaded to the systematic review management tool, Covidence (Veritas Health Innovation Ltd, Melbourne, Australia). Following the Cochrane Handbook of Systematic Reviews and the PRISMA Statement for study selection, two researchers (RR and SSJ) independently screened titles and abstracts against the inclusion and exclusion criteria. Any disagreements were discussed and resolved by consensus between two authors (RR and SSJ). Where a decision was unresolved, a third author (SRP) was consulted.

Data Collection Process

For studies meeting the inclusion criteria, information was extracted using a pre-designed electronic data extraction table in Covidence. Two authors independently extracted the data (RR and SSJ) and a third author independently cross-checked a 20% random sample for accuracy (AT). Extracted data included primary outcome data of interest and information on participant characteristics, study characteristics and intervention characteristics. Corresponding authors were contacted for missing, incomplete or unclear data.

Data Synthesis and Analysis

A qualitative synthesis of baseline participant and overall study and intervention characteristics, as well as primary outcome data of interest and data on intervention satisfaction, engagement and adherence was completed. Primary outcome data were grouped by each mental health or wellbeing outcome for a quantitative synthesis. For example, any data from studies that measured change in anxiety between groups was pooled. Where possible, for all study arms, the mean and standard deviation for the outcome of interest was extracted at baseline, post intervention and any follow-ups. Next, data was entered into Review Manager (RevMan; version 5.4, Cochrane, London, UK) software for meta-analyses. If studies included multiple intervention arms, only the most complex intervention was used in the meta-analyses, defined as having the largest number of intervention components. All outcomes of interest were continuous in distribution. Where two or more studies measured the same continuous outcome, they were combined using an inverse variance random effects model, using the standardised mean difference (SMD) and 95% confidence interval (CI). Results of the meta-analyses are presented using forest plots for each outcome. Heterogeneity between studies was assessed using tau^2 and the I^2 statistic. I^2 statistic of $> 50\%$ indicate substantial heterogeneity between studies. Significance of heterogeneity was identified using the Cochran's Q (χ^2) test ($P < 0.1$). Sensitivity analyses were performed excluding the studies with high risk of bias to elucidate whether this caused any difference in the pooled results. For each outcome, small-study effects were evaluated using funnel plots. The published protocol was adhered to in full, however once data was synthesized the protocol was amended to add the sensitivity analysis to understand whether removing studies at high risk of bias improved precision, reduced possible heterogeneity and improved the reliability of the pooled effects.

Risk of Bias Assessment

The Cochrane Collaboration's tool was used to assess the risk of bias at the individual study level (Sterne et al., 2019). Two Cochrane Risk of Bias tools were used: for randomized trials (RoB 2) and for cRCTs (RoB 2 cRCT). The RoB 2 and RoB 2 cRCT domains for risk of bias assessment included randomization process, deviations from the intended interventions, missing outcome data, measurement of the outcome and selection of the reported result. The judgement within each domain was assessed to produce an overall risk of bias judgement as low risk, some concerns or high risk of bias. Two authors (RR and SJ) independently evaluated

each study for risk of bias. Any discrepancies were resolved by a third author (SRP).

Results

Study Selection

The search found 5362 articles from all electronic database searches. After exclusion of duplicates, 5229 articles were screened by title and abstract and 5089 were excluded. A total of 140 full-text articles were assessed for eligibility and 123 were excluded with reasons listed in Fig. 1. Seventeen full-text articles representing 17 unique studies were included in this review.

Participant and Study Characteristics

Thirteen of the studies were RCTs and four were cRCTs. All were published in English. Seven studies were conducted in the USA, three in the Netherlands, and one each in Hong Kong, Iceland, Spain, Australia, Taiwan, Turkey and Thailand. There was a total of 9070 participants, ranging in age from 10 to 24 years, with a pooled mean age (pooled SD) of 15.3 (1.2). On average, 55.8% of participants were female (range 16–100%). Interestingly, some studies only reported a percentage of how many participants identified as male/female/other and therefore the exact number of participants for each gender is not presented. 12/17 (70.6%) of studies reported ethnicity. Three studies included only participants of one ethnicity (n = 2 Chinese and n = 1 Thai) (Chan et al., 2022; Chen et al., 2018; Likhitweerawong et al., 2021). Five

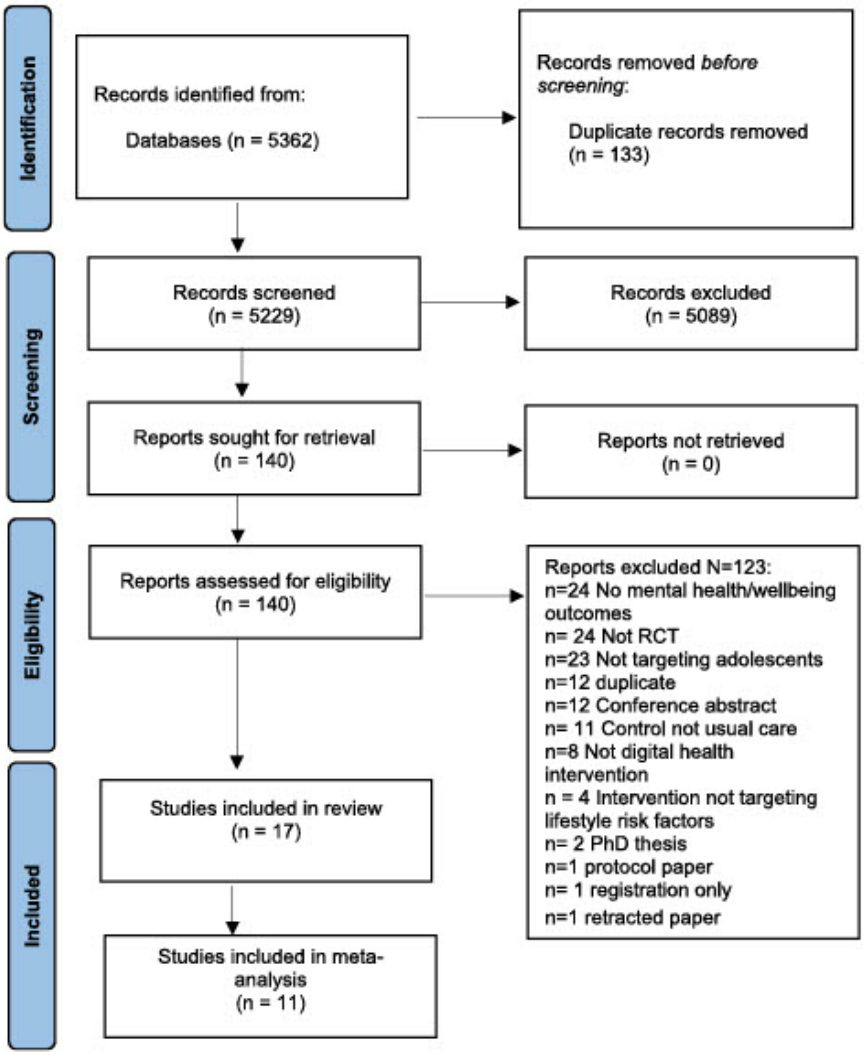


Fig. 1 PRISMA flowchart of study selection

Table 1 Participant characteristics of included studies

Author, year, country	Age range (years)	Mean age, years (SD)	Gender, n (%)	Ethnicity (n/N, %)	Education (n/N, %)	Income/socioeconomic status (n/N, %)	Weight status at baseline	Recruited from school/university/college setting?
Chan et al., 2022, Hong Kong	12–24	ESH: 20.9 (2.5) GT: 19.4 (2.3) WT: 19.7 (2.6)	M: 32.6% F: 67.4%	Chinese (135/135, 100)	Master: (7/135, 5.1) Undergraduate: (97/135, 71.9) Secondary: 31/135 (23.0)	NR	NR	Y – secondary schools and universities
Chen et al, 2018, USA	13–18	14.9 (1.67)	M: 23 (57.5) F: 17 (42.5)	Chinese American (40/40, 100)	NR	95% of study participants reported annual family income < $40,000	BMI ≥ 85th percentile	N—recruited from community clinics
Cremers et al, 2015, Netherlands	10–11	Prompt: 10.36 (0.55) No-prompt: 10.35 (0.54) Control: 10.38 (0.55)	M: 1588 (49.4) F: 1625 (50.6)	Western (2836/3213, 88.2)	NR	SES (high) (1354/3213, 42.1)	NR	Y—primary schools
De Bruin et al, 2016, Netherlands	12–19	IT: 15.3 (1.4) GT: 15.6 (1.7) WL: 15.9 (1.6)	M: 29 (25.0) F: 87 (75.0)	Parent country of birth, Netherlands (93/116, 80.2) Parent country of birth, other (10/116, 8.6) Parent country of birth, missing (13/116, 11.2)	Parent education High school or less (2/116, 1.7) Some college: (35/116, 30.2) College graduate: (30/116, 25.9) Graduate school: (35/116, 30.2) Other: (1/116, 0.9) Missing: (13/116, 11.2)	NR	NR	N—recruited from advertisements, newsletters, lectures at schools and leaflets for healthcare professionals
Egilsson et al, 2021, Iceland	15–16	I: 15.64 (0.25) C: 15.6 (0.26)	M: 24 (58.5) F: 17 (41.5)	NR	Current student (41/41, 100)	NR	BMI Category Underweight (7/41, 17.1%) Healthy weight (25/41, 60.9%) Overweight (1/41, 2.4%) Obesity 1/41, 2.4%) Missing (7/41, 17.1%)	Y – recruited from schools

Table 1 (continued)

Author, year, country	Age range (years)	Mean age, years (SD)	Gender, n (%)	Ethnicity (n/N, %)	Education (n/N, %)	Income/socioeconomic status (n/N, %)	Weight status at baseline	Recruited from school/university/college setting?
Graham et al, 2021, USA	18–24	I: 20.4 (1.7) C: 20.4 (1.7)	M: 1253 (48.4) F: 1303 (50.3) Nonbinary/other: 26 (1.0) Refused: 6 (0.2)	White (2159/2588, 83.4) Asian (128/2588, 4.8) Black (38/2588, 1.5) American Indian/Alaska native (18/2588, 0.7) Multiracial (162/2588, 6.3) Other (50/2588, 1.9) Refused (28/2588, 1.1)	Current student (1932/2588, 74.7)	Lives comfortably (673/2588, 26.0) Meets needs with a little left (1000/2588, 36) Just meets basic expenses (778/2588, 30.1) Does not meet basic expenses (37/2588, 5.3)	NR	N—recruited via advertisements on Facebook and Twitter
Guo et al, 2014, Taiwan	High school students	I: 16.05 (0.91) C: 16.08 (0.68)	M: NR (83.92) F: NR (16.08)	NR	Parent education ≤ 12 years (NR, 94.89) ≥ 12 years (NR, 5.11)	Parent occupation White collar (NR, 18.38) Blue collar (NR, 81.62)	NR	Y—vocational high schools
Jones et al, 2008, USA	High school students	I: 15.0 (1.0) C: 15.2 (1.1)	M: 32 (30.5) F: 73 (69.5)	White (67/105, 63.8) Black (8/105, 7.6) Latino/Hispanic/Mexican (22/105, 21.0) Other (8/105, 7.6)	Mothers' education Less than high school (7/105, 6.7) Finished high school (31/105, 29.5) More than high school (56/105, 53.3) Unknown (11/105, 10.5) Fathers' education Less than high school (9/105, 8.6) Finished high school (22/105, 21.0) More than high school (54/105, 51.4) Unknown (20/105, 19.0)	NR	BMI ≥ 85th percentile	Y—high schools

Table 1 (continued)

Author, year, country	Age range (years)	Mean age, years (SD)	Gender, n (%)	Ethnicity (n/N, %)	Education (n/N, %)	Income/socioeconomic status (n/N, %)	Weight status at baseline	Recruited from school/university/college setting?
Köse and Yıldız, 2021, Turkey	12–18	14.38 (1.53)	M: 25 (39.1) F: 39 (60.9)	NR	Mothers' education Illiterate (3/64, 4.7) Primary school (33/64, 51.6) Secondary school (10/64, 15.6) High school (9/64, 14.1) University (9/64, 14.1) Fathers' education Primary school (28/64, 43.8) Secondary school (12/64, 18.8) High school (13/64, 20.3) University (11/64, 17.2)	Perceived income level Poor (3/64, 4.7) Medium (40/64,62.5) Good (21/64, 32.8)	With overweight or obesity	N—recruited from Adolescence Polyclinic
Likhitweerawong et al, 2021, Thailand	10–15	I: 13.11 (1.99) C: 12.81 (1.79)	M: 48 (68.6) F: 22 (31.4)	Thai (70/70, 100)	NR	NR	BMI ≥ 95th percentile	Y – school and hospital-based settings
Lopez et al, 2021, USA	14–18	15.39 (1.26)	M: 31 (40.79) F: 45 (59.21)	Hispanic (50/76, 65.79) Non-Hispanic (26/76, 34.21)	Parent education High school or less (44/76, 57.89) Trade/vocational (7/76, 9.21) College (22/76, 28.95) Graduate degree (3/76, 3.95)	Household income < $50 k (50/76, 65.79) $50 k–$149,999 (16/76, 21.05) ≥ $150 k (5/76, 6.58) NR (5/76, 6.58)	BMI ≥ 85th percentile	N—recruited from paediatric clinics at hospital, direct mailing campaign and community
Lubans et al, 2012, Australia	8th grade high school students	I: 13.15 (0.44) C: 13.20 (0.45)	F: 357 (100)	Australian (305/357, 85.4) Asian (4/357, 1.1) European (36/357, 10.1) Other (11/357, 3.1)	NR	Socioeconomic position 1–2 (75/357, 21.1 3–4 (87/357, 24.5) 5–6 (183/357, 51.3) 7–8 (9/357, 2.5) 9–10 (1/357, 0.3)	BMI category Underweight (2/357, 0.6) Healthy weight (202/357, 56.6%) Overweight (93/357, 26.1) Obese (60/357, 16.8)	Y—high schools

Table 1 (continued)

Author, year, country	Age range (years)	Mean age, years (SD)	Gender, n (%)	Ethnicity (n/N, %)	Education (n/N, %)	Income/socioeconomic status (n/N, %)	Weight status at baseline	Recruited from school/university/college setting?
Richardson et al, 2021, USA	13–18	NR	M: 168 (56.0) F: 129 (43.0) Trans or nonbinary: 3 (1.0)	I: White: 93 (64.1%) Hispanic: 7 (4.8%) African American: 6 (4.2%) Asian or Pacific Islander: 7 (4.8%) Native American: 1 (0.7%) Other or more than one: 31 (21.4%) C: White: 99 (63.9%) Hispanic: 12 (7.7%) African American: 13 (8.4%) Asian or Pacific Islander: 7 (4.5%) Native American: 0 (0%) Other or more than one: 24 (15.5%)	NR	NR	NR	N—recruited from paediatric clinics
Rodgers et al, 2018, USA	14–19	18.36 (1.34)	M: 26% F: 74%	White (154/274, 56) Asian (51/274, 19) Black (28/274, 10) Hispanic (23/274, 8) Other (18/274, 7)	NR	NR	NR	Y—2 high schools, 2 local youth organisations and 1 university campus
Slootmaker et al, 2010, Netherlands	13–17	Overall: 15.1 I: M: 15.3 (1.1), F: 15.4 (1.1) C: M: 14.8 (1.4), F: 15.0 (1.2)	M: 32 (37) F: 55 (63)	NR	High education: 61% I: M: 87%, F: 54% C: M: 59%, F: 55%	NR	NR	Y—secondary schools

Table 1 (continued)

Author, year, country	Age range (years)	Mean age, years (SD)	Gender, n (%)	Ethnicity (n/N, %)	Education (n/N, %)	Income/socioeconomic status (n/N, %)	Weight status at baseline	Recruited from school/university/college setting?
Thompson et al., 2016, USA	14–17	NR	M: 77 (48.13) F: 83 (51.88)	Hispanic (43/160, 26.88) White (50/160, 31.25) African American (57/160, 35.63) Mixed/Other (10/160, 6.25)	NR	NR	NR	N—recruited through community
Vargas-Martínez et al., 2019, Spain	15–19	I: 16.87 (1.06) C: 16.68 (1.04)	F: 53.01	94.7% Spanish I: 0.954 (0.21) C: 0.936 (0.24)	Mother's schooling years I: 20.39 (27.07) C: 22.68 (29.00) Mean schooling years of mothers: 11.48 Mean schooling years of fathers: 11.17	Good economic situation at home I: 0.45 (0.50) C: 0.49 (0.50) Good or very good 62.27%	NR	Y—secondary or higher secondary schools or first course of vocational training (10^{th} and 11^{th} grade USA equivalent)

BMI body mass index, *C* control, *ESH* Email Self Help, *F* female, *GT* Group Therapy, *I* intervention, *IT* Internet therapy, *M* male, *NR* not reported, *WL* waitlist control, *WT* Waitlist

of the studies were targeted at adolescents who had overweight or obesity (Chen et al., 2018; Jones et al., 2008; Köse & Yıldız, 2021; Likhitweerawong et al., 2021; Lopez et al., 2021). For further participant details please refer to Table 1. Length of follow-up ranged from 1 to 25 months. Nine studies targeted more than one lifestyle risk factor (9/17, 52.9%) (Chen et al., 2018; Egilsson et al., 2021; Jones et al., 2008; Köse & Yıldız, 2021; Lopez et al., 2021; Lubans et al., 2012; Richardson et al., 2021; Rodgers et al., 2018; Slootmaker et al., 2010). Three studies targeted smoking only (Cremers et al., 2015; Graham et al., 2021; Guo et al., 2014), two studies targeted sleep only (Chan et al., 2022; De Bruin et al., 2016) and one each targeted only diet (Likhitweerawong et al., 2021), physical activity (Thompson et al., 2016), and alcohol (Vargas-Martínez et al., 2019). Five studies specifically targeted adolescents with overweight or obesity (Chen et al., 2018; Jones et al., 2008; Köse & Yıldız, 2021; Likhitweerawong et al., 2021; Lopez et al., 2021). Attrition rates across studies varied, with four studies having attrition rates above 30% (Cremers et al., 2015; De Bruin et al, 2016; Egilsson et al., 2021; Vargas-Martínez et al., 2019). Full details of participant and study characteristics are available in Table 1 and 2 respectively.

Intervention Characteristics

The method of delivering digital health interventions varied across the 17 studies. Four interventions used a combination of digital health delivery methods including fitness trackers (Chen et al., 2018), websites (Chen et al., 2018; Cremers et al., 2015; Richardson et al., 2021), mobile phone applications (Chen et al., 2018; Lopez et al., 2021; Richardson et al., 2021) and text messaging (Chen et al., 2018; Cremers et al., 2015; Lopez et al., 2021). Five interventions were delivered via text messaging alone (Graham et al., 2021; Guo et al., 2014; Köse & Yıldız, 2021; Lubans et al., 2012; Thompson et al., 2016), four were delivered through a website (De Bruin et al., 2016; Jones et al., 2008; Slootmaker et al., 2010; Vargas-Martínez et al., 2019), three were mobile phone applications (Egilsson et al., 2021; Likhitweerawong et al., 2021; Rodgers et al., 2018) and one was delivered via email (Chan et al., 2022). Intervention duration ranged from 6 weeks (De Bruin et al., 2016; Egilsson et al., 2021; Rodgers et al., 2018) to 12 months (Cremers et al., 2015; Lubans et al., 2010). Eleven of the interventions had the digital component only (Chan et al., 2022; Cremers et al., 2015; De Bruin et al., 2016; Egilsson et al., 2021; Graham et al., 2021; Jones et al., 2008; Likhitweerawong et al., 2021; Richardson et al., 2021; Rodgers et al., 2018; Slootmaker et al., 2010; Vargas-Martínez et al., 2019), whereas six studies were multicomponent and included the digital component alongside other intervention components e.g. classroom curriculum, interactive workshops (Chen et al., 2018; Guo et al.,

2014; Köse & Yıldız, 2021; Lopez et al., 2021; Lubans et al., 2012; Thompson et al., 2016). Due to the complexity across interventions in terms of duration, components and exposure, the results are unable to be pooled to adequately demonstrate frequency of intervention exposure. There were several behavior change theories underpinning the interventions including cognitive behavioral therapy (CBT) (Chan et al., 2022; De Bruin et al., 2016; Jones et al., 2008), social cognitive theory (SCT) (Chen et al., 2018; Graham et al., 2021; Lubans et al., 2012), I-Change Model (Cremers et al., 2015; Vargas-Martínez et al., 2019), motivational interviewing (Köse & Yıldız, 2021) and self-determination theory (SDT) (Thompson et al., 2016). Five of 17 studies used co-design with adolescents in intervention development (Egilsson et al., 2021; Graham et al., 2021; Guo et al., 2014; Richardson et al., 2021; Thompson et al., 2016). Full details of the intervention characteristics are available in Table 3.

Mental Health or Wellbeing Outcomes

For two of the included studies, the outcome data of interest was not presented in the manuscript and was unavailable after contacting the corresponding author (Cremers et al., 2015; Thompson et al., 2016). All data used in the meta and sensitivity analyses are available in Supplementary File 3. Forest plots for meta-analyses are available in Fig. 2. Forest plots for sensitivity analysis are available in Fig. 3.

Quality of Life

Four studies (4/17, 23.5%) measured quality of life (QOL) (Chen et al., 2018; Köse & Yıldız, 2021; Likhitweerawong et al., 2021; Vargas-Martínez et al., 2019), with all having sufficient data to perform meta-analyses and used two QOL measures that are validated in adolescent populations: Pediatric Quality of Life Inventory (PedsQL) (Chen et al., 2018; Köse & Yıldız, 2021; Likhitweerawong et al., 2021) and EQ-5D-5L (Vargas-Martínez et al., 2019). One study measured QOL as the primary outcome (Vargas-Martínez et al., 2019). Only one study showed significant effects of the intervention (Köse & Yıldız, 2021), which used text messaging to deliver the intervention over 6-months. Two separate meta-analyses were performed due to one paper reporting QOL for the physical and psychosocial subscales separately and not the total summary score. Overall, meta-analyses indicated that compared with usual care controls, interventions increased physical QOL levels but did not reach a significant level (SMD 0.30, 95% CI − 0.05 to 0.66, P = 0.10). There was significant heterogeneity amongst studies ($Tau^2 = 0.09$, $I^2 = 70\%$; P = 0.02). Similarly, interventions increased psychosocial QOL levels but did not reach a significant level compared to control with significant heterogeneity amongst studies (SMD 0.38, 95% CI − 0.08 to 0.83, P = 0.10; $Tau^2 = 0.16$, $I^2 = 82\%$, P = 0.001). One study had high RoB (Köse & Yıldız, 2021) and therefore the sensitivity analysis was performed on the remaining three studies. For physical QOL, the sensitivity analyses showed non-significant positive effects of the intervention (SMD 0.05, 05% CI − 0.06 to 0.16; P = 0.37) with no heterogeneity ($Tau^2 = 0.00$, $I^2 = 0\%$, P = 0.41). For psychosocial QOL, there was also non-significant positive effects of the intervention compared to control (SMD 0.17, 95% CI − 0.18 to 0.52; P = 0.34) and there was substantial heterogeneity across studies ($Tau^2 = 0.06$, $I^2 = 59\%$, P = 0.09).

Self-efficacy

Five (5/17, 29.4%) studies measured self-efficacy (Chen et al., 2018; Cremers et al., 2015; Egilsson et al., 2021; Guo et al., 2014; Slootmaker et al., 2010). Self-efficacy was measured across different domains including physical activity (Chen et al., 2018; Slootmaker et al., 2010), nutrition (Chen et al., 2018), smoking cessation (Cremers et al., 2015; Guo et al., 2014) and general self-efficacy (Egilsson et al., 2021). Due to this variability, meta-analysis was not possible. Three studies used study-specific questionnaires (Cremers et al., 2015; Guo et al., 2014; Slootmaker et al., 2010), one study used the Health Behavior Questionnaire (Chen et al., 2018) and one used the General Self Efficacy Scale (GSE) (Egilsson et al., 2021). Both the Health Behavior Questionnaire and GSE have been validated in adolescent populations previously. No studies measured self-efficacy as a primary outcome. Significant effects of the intervention were seen across three studies measuring physical activity and nutrition self-efficacy (Chen et al., 2018), self-efficacy in smoking cessation (Guo et al., 2014) and self-efficacy in sports (significant among males only) (Slootmaker et al., 2010).

Depressive Symptoms

Six studies measured depressive symptoms (6/17, 35.3%) (Chan et al., 2022; Egilsson et al., 2021; Graham et al., 2021; Jones et al., 2008; Lopez et al., 2021; Richardson et al., 2021), with five having sufficient data for meta-analyses (Chan et al., 2022; Egilsson et al., 2021; Graham et al., 2021; Jones et al., 2008; Lopez et al., 2021). Depressive symptoms were measured using various validated measures including Hospital Anxiety and Depression Scale (HADS) (Chan et al., 2022), Children's Depression Inventory (CDI) (Egilsson et al., 2021), Patient Health Questionnaire-2 (PHQ-2) (Graham et al., 2021) and Center for Epidemiological Studies Depression Scale for Children (CES-DC) (Jones et al., 2008; Lopez et al., 2021). No studies measured depressive symptoms as the primary outcome. Overall, the results of the meta-analysis revealed that compared

with usual care controls, interventions decreased depressive symptoms but did not reach a significant level compared to control (SMD − 0.02, 95% CI − 0.09 to 0.05, P = 0.60) and results were homogenous across studies ($Tau^2 = 0.00$, $I^2 = 0\%$, P = 0.60). For depressive symptoms, three studies had a high RoB (Egilsson et al., 2021; Jones et al., 2008; Lopez et al., 2021) and sensitivity analysis was performed on the remaining two studies. Sensitivity analysis showed a non-significant decrease in depressive symptom levels comparing intervention to usual care controls (SMD − 0.05, 95% CI − 0.21 to 0.12; P = 0.59), and results had little heterogeneity ($Tau^2 = 0.01$, $I^2 = 23\%$, P = 0.26).

Anxiety

Four studies measured anxiety (4/17, 23.5%) all with sufficient data for meta-analyses (Chan et al., 2022; De Bruin et al., 2016; Egilsson et al., 2021; Graham et al., 2021). Anxiety was measured using the following questionnaires: Hospital Anxiety and Depression Scale (HADS) (Chan et al., 2022), Youth Self Report (De Bruin et al., 2016), Multidimensional Anxiety Scale (MASC) (Egilsson et al., 2021) and Generalized Anxiety Disorder (GAD-2) (Graham et al., 2021). No studies measured anxiety as the primary outcome. Overall, meta-analysis showed that compared with usual care controls, interventions decreased anxiety levels but did not reach a significant level with substantial heterogeneity amongst studies (SMD − 0.13, 95% CI − 0.45 to 0.19, P = 0.42; $Tau^2 = 0.07$, $I^2 = 69\%$; P = 0.02). Two of the studies measuring anxiety had a high RoB (De Bruin et al., 2016; Egilsson et al., 2021). The sensitivity analysis on two remaining studies (Chan et al., 2022; Graham et al., 2021), showed a non-significant decrease in anxiety levels comparing intervention to usual care controls in the sensitivity analysis (SMD − 0.04, 95% CI − 0.11 to 0.04) and results were homogenous across trials ($Tau^2 = 0.00$, $I^2 = 0\%$, P = 0.61).

Positive and Negative Affect

One study measured both positive and negative affect (Rodgers et al., 2018) and one study measured negative affect only (De Bruin et al., 2016). Although meta-analysis is recommended for 2 or more studies for better precision, significant heterogeneity existed between studies for negative affect and therefore results are summarised in a narrative synthesis. Affect was measured using Youth Self Report (De Bruin et al., 2016) and Positive and Negative Affect Schedule Children (PANAS-C) (Rodgers et al., 2018). No studies measured affect as the primary outcome. Rodgers and colleagues found no interaction effects for positive or negative affect and De Bruin and colleagues found no significant intervention effects on negative affect.

Self-esteem

One study measured self-esteem as a secondary outcome (Lubans et al., 2010, 2012) using the selective scales from Marsh's Physical Self-Description Questionnaire which is validated in an adolescent population. There were no significant effects of the intervention on self-esteem.

Intervention Satisfaction, Engagement and Adherence

Data on intervention satisfaction, engagement and adherence was poorly reported across studies. Four of 17 (23.5%) studies reported data on intervention satisfaction for participants, with over half of participants finding interventions acceptable (satisfaction 57–91%) (Egilsson et al., 2021; Lubans et al., 2012; Slootmaker et al., 2010; Thompson et al., 2016). Eight of 17 (47.1%) studies reported data on participant engagement or adherence with the intervention, assessed by the amount of the intervention received or accessed by participants which ranged from 22.5% to 83.1% across studies (Chan et al., 2022; Egilsson et al., 2021; Jones et al., 2008; Likhitweerawong et al., 2021; Lopez et al., 2021; Lubans et al., 2012; Slootmaker et al., 2010; Vargas-Martínez et al., 2019). Adherence to the intervention was reported to drop over time in five studies (Chan et al., 2022; Egilsson et al., 2021; Jones et al., 2008; Slootmaker et al., 2010; Vargas-Martínez et al., 2019). One study had a technical issue and therefore could not assess engagement or adherence (Rodgers et al., 2018).

Risk of Bias

Table 4 and 5 and Figs. 4 and 5 summarise the risk of bias assessment for RCTs and cRCTs. Nine of 17 studies (52.9%) had an overall RoB judged as high (Cremers et al., 2015; De Bruin et al., 2016; Egilsson et al., 2021; Guo et al., 2014; Jones et al., 2008; Köse & Yıldız, 2021; Lopez et al., 2021; Lubans et al., 2012; Rodgers et al., 2018). Twelve of 17 studies (76.5%) were judged as some concerns or high in the domain'risk of bias due to deviations from intended intervention', largely due to not blinding the participants and study personnel to intervention assignment, which is typically not possible in digital health interventions. Three of these studies also did not use appropriate analysis techniques for their data (Köse & Yıldız, 2021; Lopez et al., 2021; Rodgers et al., 2018). Across cRCTs, all were judged as some concerns for their randomization process as no information was provided. Of the four cRCTs, two had baseline differences between groups (Cremers et al., 2015; Vargas-Martínez et al., 2019). No significant publication bias was found from assessing funnel plots (Supplementary File 4).

Table 2 Study characteristics of included studies

Author, year, country	Study design	Total (n)	Intervention (n)	Control (n)	Risk factors targeted (n, type)	Duration of Intervention	Follow-up(s)	Attrition at follow-up(s) (from baseline)	Primary Outcome	Secondary Outcomes
Chan et al., 2022, Hong Kong	RCT	135	ESH: 45 GT: 45	45	1, Sleep	8 weeks	Post intervention, 1, 6 months	Post intervention: ESH: 18; GT: 2 WL: 15 1 month: ESH: 2; GT: 4 6 months: ESH: 1; GT: 4	Not relevant	Clinician rated depressive symptoms (HRSD) Self-reported mood symptoms (depression and anxiety): HADS
Chen et al, 2018, USA	RCT	40	23	17	3, Diet, PA, SB	3 months	3, 6 months	3 months: 0 6 months: I: 2, C: 2	Not relevant	Self-efficacy for healthy eating and PA: Health Behavior Questionnaire Paediatric QOL: PQOL-Adolescents
Cremers et al, 2015, Netherlands	Cluster RCT	3213	Prompt: 1207 No-Prompt: 1003	1003	1, Smoking	12 months	12 (T1), 25 (T2) months	T0–T1: 1067 T0–T2: 1730	Not relevant	Self-efficacy expectations for refusing cigarettes
De Bruin et al, 2016, Netherlands	RCT	116	IT: 39 GT: 38	WL: 39	1, Sleep	6 weeks	2, 6, 12 months	2 months: IT: 1, GT: 2, WL: 2 6 months: IT: 16, GT: 17 12 months: IT: 22, GT: 20	Not relevant	Anxiety problems, affective problems: YSR
Egilsson et al, 2021, Iceland	RCT	41	20	21	2, Diet, PA	6 weeks	Post intervention	Post intervention: I: 11, C: 8	Not relevant	General self-efficacy: GSE Depressive symptoms: CDI Anxiety: MASC
Graham et al, 2021, USA	RCT	2588	1304	1284	1, Smoking	9–12 weeks (depending on readiness to quit)	1, 7 months	1 month: I: 292, C: 239 7 months: I: 331, C: 290	Not relevant	Depressive symptoms: PHQ-2 Anxiety: GAD-2
Guo et al, 2014, Taiwan	Cluster RCT	143	79	65	1, Smoking	12 weeks	Post intervention, 1, 4 months	Post intervention: I: 12, C: 1 1 month: I: 16, C: 3 4 months: I: 25, C: 16	Not relevant	Self-efficacy in smoking cessation
Jones et al, 2008, USA	RCT	105	52	53	3, Diet, PA, SB	16 weeks	16 weeks, 9 months	16 weeks: I: 6, C: 5 9-months: I: 8, C: 8	Not relevant	Depressive symptoms: CES-D 20
Kose et al., 2020, Turkey	RCT	80	43	37	2, Diet, PA	6 months	6 months	I: 6, C: 10	Not relevant	QOL: PedsQL

Table 2 (continued)

Author, year, country	Study design	Total (n)	Intervention (n)	Control (n)	Risk factors targeted (n, type)	Duration of Intervention	Follow-up(s)	Attrition at follow-up(s) (from baseline)	Primary Outcome	Secondary Outcomes
Likhitweerawong et al, 2021, Thailand	RCT	70	35	35	1, Diet	6 months	6 months	6 months: I: 3; C: 4	Not relevant	QOL: PedsQL
Lopez et al, 2021, USA	RCT	113	AppCoach: 37 AppAlone: 38	38	2, Diet, PA	6 months	6 months	AppCoach:3 AppAlone: 11 C: 7	Not relevant	Depressive symptoms: CES-DC 10
Lubans et al, 2012, Australia	Cluster RCT	357	178	179	2, Diet, PA	12 months	12 months	I: 37, C: 26	Not relevant	Physical and global self-esteem: Marsh's Physical Self-description questionnaire
Richardson et al, 2021, USA	RCT	301	145	155	3, Diet, PA, Sleep	3 months	3, 6 months	3 months: I: 7, C: 10 6 months: I: 6, C: 10	Not relevant	Depressive symptoms: Risk Behavior Outcome
Rodgers et al, 2018, USA	RCT	274	129	130	3, Diet, PA, Sleep	6 weeks	6 (T2), 12 (T3) weeks	T2: 23, T3: 37	Not relevant	Positive and Negative Mood: Positive and Negatvie Affect Schedule 10-Children
Slootmaker et al, 2010, Netherlands	RCT	87	41	46	2, PA, SB	3 months	3, 8 months	3 months: I: 7, C: 12 8 months: I: 3, C: 5	Not relevant	Self-efficacy for sports participation, walking and biking and reducing screentime
Thompson et al, 2016, USA	RCT	160	P: 40 P+GP: 40 P+GP+T: 40	40	1, PA	12 weeks	12 weeks	C: 6, P: 4, P+GP: 9, P+GP+T: 3	Not relevant	Psychosocial variables: Basic Psychological Needs Satisfaction Questionnaire
Vargas-Martínez et al., 2019, Spain	Cluster RCT	1247	742	505	1, Alcohol	4 months	4 months	I: 393, C: 242	Health related QOL: EQ-5D-5L	Not relevant

C control, *CDI* Children's Depression Inventory, *CES-D* Center for Epidemiological Studies Depression Scale, *CES-DC* Center for Epidemiological Studies Depression Scale of Children, *EQ-5D-5L* EuroQol 5 Dimension 5 Level, *ESH* Email Self Help, *GAD-2* Generalized Anxiety Disorder 2-item, *GSE* General Self-Efficacy, *GT* Group Therapy, *HADS* Hospital Anxiety and Depression Scale, *HRSD* Hamilton Depression Rating Scale, *I* intervention, *IT* Internet Therapy, *MASC* Multidimensional Anxiety Scale for Children, *P+GT* Pedometer+Goal Prompt, *P+GT+T* Pedometer+Goal Prompt+Texts, *PA* physical activity, *PedsQL* Pediatric Quality of Life, *PHQ-2* Patient Health Questionnaire 2-item, *QOL* Quality of Life, *RCT* Randomised Controlled Trial, *SB* Sedentary Behavior, *SDT* self determination theory, *WL* waitlist, *YSR* Youth Self-Report

Table 3 Intervention characteristics of included studies

Intervention group	Theory for intervention	Digital health delivery method	Contact with research personnel	Intervention details and exposure	Comparator
Chan et al, 2022, Hong Kong					
ESH[a]	Cognitive behavioral therapy	Email	Weekly reminders to complete sleep diary	Weekly email with treatment materials for 8 weeks	Usual care
GT	Cognitive behavioral therapy	N/A	1 × week for 8 weeks	Group face-to-face CBT session once a week for 8 weeks	
Chen et al, 2018, USA					
iStart Smart for Teens	Social cognitive theory	Fitness tracker, website, mobile phone (app, program, text messaging)	In-person demonstration to access Fitbit data and iStart Smart for Teens program	Wearable sensor—Fitbit Flex (6-months) 8 online educational modules (months 1–3) Tailored, bi-weekly text messages (months 3–6)	Pedometer, blank food and activity diary, online program with 8 modules related to general adolescent health
Cremers et al, 2015, Netherlands					
Prompt[a]	I-Change Model	Website, text messaging	N/A	12-months access to 'Fun without Smokes' website: smoking and non-smoking information, animated videos with non-smoking content, games concerning non-smoking 3 × web-based computer-tailored feedback messages 6 × prompt messages via email and SMS every year to stimulate reuse of the website	Website access during three measurement sessions only, no access to non-smoking information or interactive elements, no computer-tailored feedback or prompt messages
No-Prompt	I-Change Model	Website only	N/A	As above without prompt messages	
De Bruin et al, 2016, Netherlands					
IT[a]	Cognitive behavioral therapy	Website	15 min chat (week 2)	'Sleeping Smart' Website with personalized advice and feedback, online material (90 min to complete, once a week for six weeks), and booster session after 2-months	Usual care
GT	Cognitive behavioral therapy	N/A	1 × week for 6 weeks	Group face-to-face 90-min CBT session once a week for six weeks, and a booster session after 2-months	

Table 3 (continued)

Intervention group	Theory for intervention	Digital health delivery method	Contact with research personnel	Intervention details and exposure	Comparator
Egilsson et al, 2021, Iceland					
SidekickHealth	Education and appetite awareness training (AAT)	Mobile phone application	5-min introduction to study specifications 10-min introduction to mobile app and its functions	6 weeks access to social health mobile application where the user sets goals and creates health-related missions (gamification) in physical activity, food and drink and mental health Completion of missions and competitions accumulates badges, moves to higher levels and aggregates points	Usual care
Graham et al, 2021, USA					
This is Quitting	Social cognitive theory	Text messaging	N/A	Tailored, interactive 8-week text message program (Additional 1–4 weeks of messages pre-quitting building skills and confidence)	Usual care
Guo et al, 2014, Taiwan					
Multicomponent smoking-cessation program	N/A	Text messaging	6 courses in classroom (2×45 min sessions) 6 telephone calls 10 text messages	Strength and skill building: classroom curriculum, self-study manual, Chinese acupressure video New modes of communication: telephone counselling and text messaging Coupon-based incentives	Educational flyers related to smoking cessation
Jones et al, 2008, USA					
StudentBodies2-BED	Cognitive behavioral principles, Healthy Habits (adolescent weight loss intervention)	Website	N/A	16 weeks access to internet facilitated program with interactive components: self-monitoring journals for dietary intake, PA, weight, personal thoughts and goals and discussion group	Usual care
Kose et al., 2020, Turkey					
Motivational support programme	Motivational interviewing	Text messaging	8×30-min MI	MI: 8×30 min sessions Text messages: 2/week for 6-months Parent education programme: 2 h face-to-face	Usual care

Table 3 (continued)

Intervention group	Theory for intervention	Digital health delivery method	Contact with research personnel	Intervention details and exposure	Comparator
Likhitweerawong et al, 2021, Thailand					
OBEST application	Self-awareness and self-monitoring	Mobile phone application	Two-hour workshop to learn application instructions, recommended diet, calories, portion sizes and nutritional facts	6-months app access 1. Goals and rewards: set goal for calorie intake and portion sizes per day, input weight every 2 weeks, adjustable photo display 2. Daily dietary record: record daily food intake 3. Tips and news: monthly updated information based on WHO recommendations to lose weight and maintain healthy eating habits 4. Messaging: every 2 weeks from healthcare provider as reminder and motivation	Usual care
Lopez et al, 2021, USA					
AppCoach[a]: interactive mHealth intervention with personalized health coaching	Founded on three addiction-based principles	Mobile phone (app, text messaging)	Text messages: 5 days/week Phone call: 15 min/week Face-to face visits: 2×1 h	6-months app access: targets three addictive eating behaviors: (1) staged withdrawal from problem foods; (2) staged withdrawal from daytime and nighttime snacking between meals; (3) withdrawal from consuming excessive amounts of food at meals Self-monitoring of weight and targeted behaviors Coaching: via text messages 5 days/week, 15 min weekly phone calls and 2×1 h face-to-face visits	Usual care
AppAlone: interactive mHealth intervention only	Founded on three addiction-based principles	Mobile phone application	N/A	As above without coaching	

Table 3 (continued)

Intervention group	Theory for intervention	Digital health delivery method	Contact with research personnel	Intervention details and exposure	Comparator
Lubans et al, 2012, Australia					
NEAT Girls	Social cognitive theory	Text messaging	3 × interactive seminars 3 × nutrition workshops Text messages: weekly during term 2/3, bi-weekly during term 4	Multicomponent program: enhanced school sport sessions (60–80 min) 3 × interactive seminars 3 × nutrition workshops lunch-time physical activity sessions handbooks and pedometers for self-monitoring 4 × parent newsletters over 12 months and text messaging for social support	Usual care
Richardson et al, 2021, USA					
Check Yourself tool (adapted)	N/A	Website/Application	Well-care visit with clinician counselling	Website/application electronic screening with integrated feedback – delivery of messages that increased motivation and self-efficacy for healthy behavior	Completed electronic screening but did not receive integrated feedback
Rodgers et al, 2018, USA					
BodiMojo	Self-compassion	Mobile phone application	Assistance downloading app and guided through registration, features, activities	6 weeks access to mobile app designed around three active components: 1: intervention messages delivered twice daily through the app with 5 content areas: mindfulness, self-kindness, common humanity, body image related content: media literacy, peer influences and appearance compassion, healthy lifestyle related content: healthy eating, sleep hygiene and PA 2: mood tracking and emotional regulation 3: gratitude journaling	Usual care

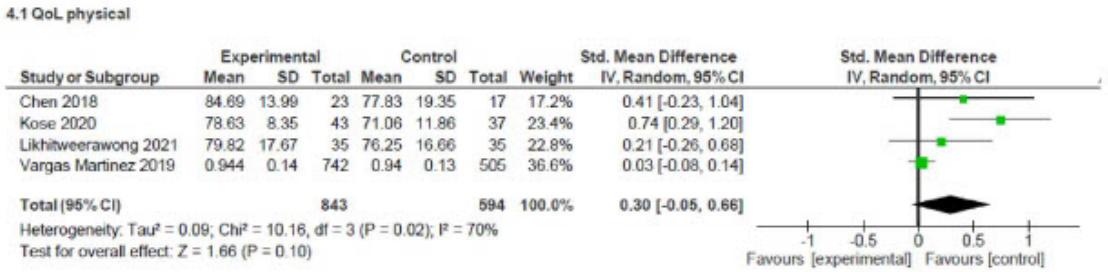
Table 3 (continued)

Intervention group	Theory for intervention	Digital health delivery method	Contact with research personnel	Intervention details and exposure	Comparator
Slootmaker et al, 2010, Netherlands					
PAM COACH	N/A	Website	Written and verbal instructions and practical demonstration on how to wear the accelerometer and use the website	PAM concept: objectively measured PA by an accelerometer with a web-based tailored PA advice (PAM COACH) accessible for 3-months	Received information brochure with brief PA recommendations
Thompson et al, 2016, USA					
Pedometer + goal prompts + SDT informed text messages[a]	Self determination theory (SDT)	Text messaging	N/A	Pedometer to track daily step count 12 Text messages to set a daily step goal for the week 72 SDT informed text messages promoting satisfaction of the basic psychological needs	Usual care
Pedometer + goal prompts	N/A	Text messaging	N/A	As above without 72 SDT informed messages	
Pedometer only	N/A	N/A	N/A	Pedometer only	
Vargas-Martínez et al., 2019, Spain					
ALERTA ALCOHOL	I-Change Model	Website	Research assistant attended session 1 to explain questionnaire	Web-based computer tailored intervention—6 sessions providing feedback through preventive messages and personalized information	Usual care

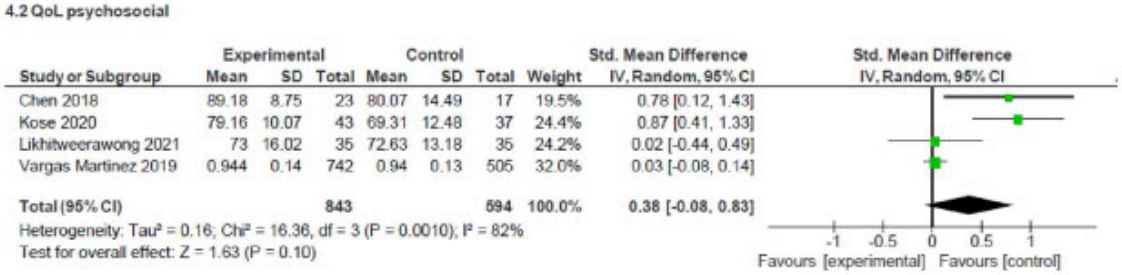
[a]'Most complex' intervention

CBT cognitive behavioral therapy, *ESH* Email Self Help, *GT* Group Therapy, *IT* Internet therapy, *MI* motivational therapy, *PA* physical activity, *SMS* Short Message Service

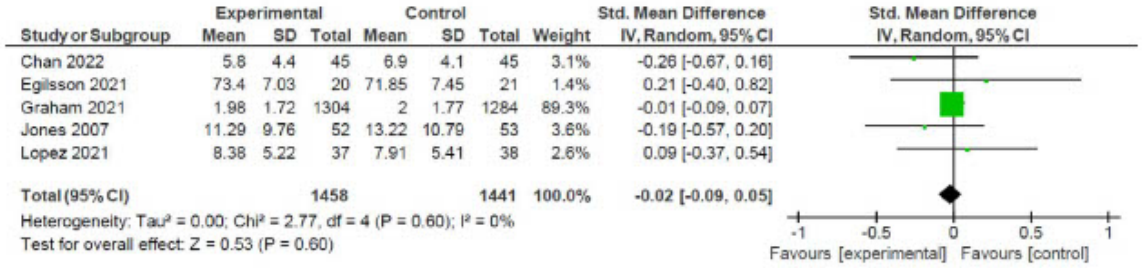
2.1 QOL physical



2.2 QOL psychosocial



2.3 Depressive symptoms



2.4 Anxiety

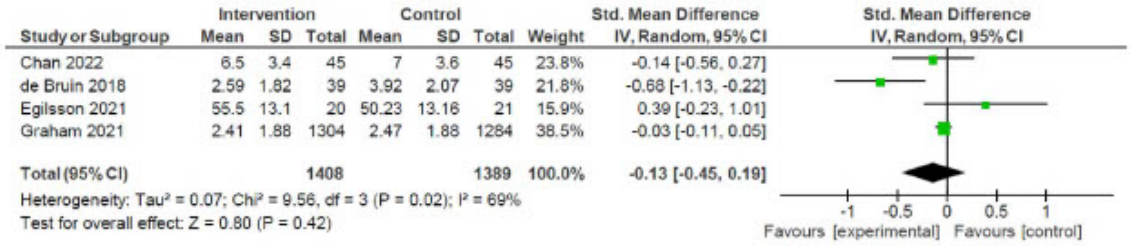
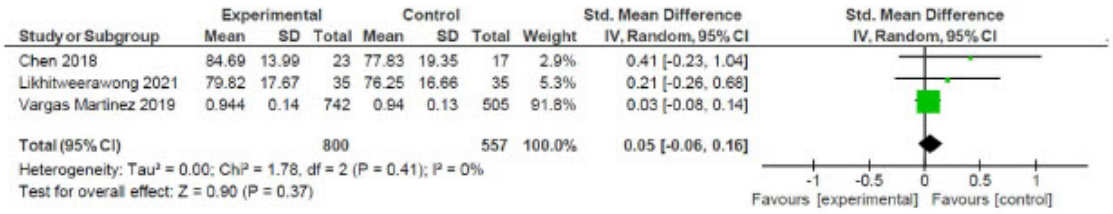
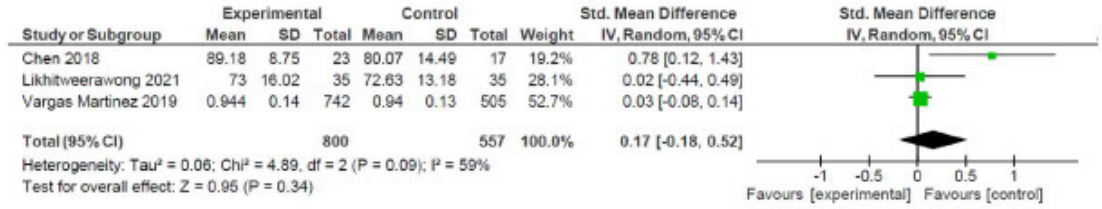


Fig. 2 Forest plots of meta-analyses. *CI* confidence interval, *IV* inverse variance, *QOL* quality of life, *SD* standard deviation

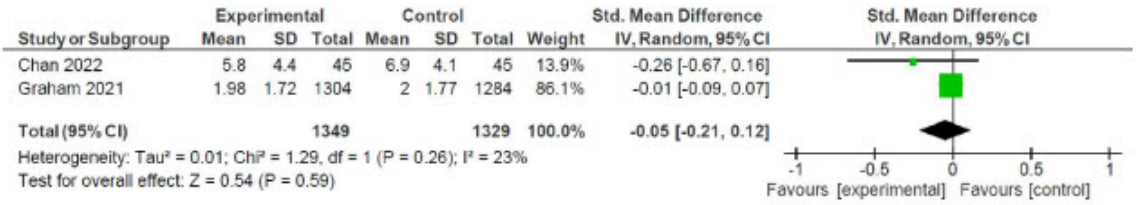
3.1 QOL physical



3.2 QOL psychosocial



3.3 Depressive symptoms



3.4 Anxiety

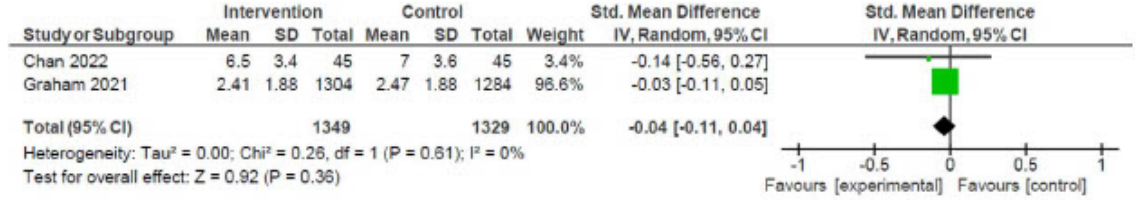


Fig. 3 Forest plots of sensitivity analyses. *CI* confidence interval, *IV* inverse variance, *QOL* quality of life, *SD* standard deviation

Discussion

Previous research has shown effectiveness of digital health interventions for improving diet and physical behaviors (Rose et al., 2017), supporting weight management (Kouvari et al., 2022) and prevention of mental health conditions among adolescents (Bantjes, 2022; Bergin et al., 2020; Werner-Seidler et al., 2020), yet no previous research informs us of the effectiveness of digital health interventions which target lifestyle risk behaviors on improving mental health or wellbeing among adolescents. This study found that digital health interventions targeting lifestyle risk behaviors among adolescents were associated with small, but non-significant improvements in quality of life, depressive

symptoms and anxiety. After excluding studies at high risk of bias, the sensitivity analyses did not change the effects. This review also showed that digital health interventions were wide-ranging in delivery method, duration and targeted risk behaviors. Co-design was rarely used in intervention development and data on intervention satisfaction, engagement and adherence were poorly reported across included studies, therefore it was unclear whether adolescents found the digital health interventions useful. Thus, mental health and wellbeing are measured outcomes in digital health interventions targeting lifestyle risk behaviors, but further work is needed to develop interventions for adolescents which have more of a holistic view, targeting the complex interplay of physical and mental health and measuring the transfer effect of one to the other.

This study identified several potential reasons for the small effects lifestyle digital health interventions can have on adolescent mental health and wellbeing. Firstly, many of the studies did not measure mental health or wellbeing as a primary outcome and so were possibly not powered to detect changes in these outcomes. Secondly, due to the sparsity of studies found in this review, results were pooled for conceptually related mental health and wellbeing outcomes (Johnston et al., 2022). Despite all being validated in an adolescent population, up to five different patient reported outcome measures were used. Furthermore, the small effect may be due to a floor effect. Incidences of mental health diagnosis for anxiety and depressive symptoms among adolescents range from 20–25% (Racine et al., 2021). As included studies only recruited otherwise healthy adolescents (i.e., no existing mental health diagnosis), participants baseline scores may have been within a healthy range and therefore only minimal improvements were seen. However, studies have shown that there are risks and considerations to both including or excluding people with a mental health diagnosis from digital mental health interventions, with consensus leaning toward ensuring that interventions are delivered to those who are in need (McCall et al., 2021). Previous research has suggested that small effects of digital health interventions targeting the prevention of mental health disorders still hold potential to have broad impact due to the increased number of adolescents able to access the intervention. Moreover, digital health interventions may be more acceptable because of the reduced stigma compared to targeted mental health interventions (Cuijpers, 2022; Montero-Marin et al., 2022). It must also be noted that five of the 17 studies only recruited adolescents who had overweight or obesity (Chen et al., 2018; Jones et al., 2008; Köse & Yıldız, 2021; Likhitweerawong et al., 2021; Lopez et al., 2021). As previous research shows, motivation is an important factor to sustain behavior change to promote weight loss in this population (Sundar et al., 2019; Woo & Park, 2020). However, this review did not choose to exclude these studies as per our protocol and due to the variation in weight categories of adolescents which exists naturally.

This review revealed that digital health interventions for lifestyle risk behaviors that assessed mental health or wellbeing outcomes were diverse, both in their content or focus and in the delivery method. Due to interest in six different lifestyle risk behaviors, the review found that nine of 17 (52.9%) interventions targeted more than one behavior, with physical activity and diet being the most prevalent. Further, only one of the 17 interventions assessed mental health or wellbeing as a primary outcome (Vargas-Martínez et al., 2019). Interventions targeting lifestyle risk behaviors that specifically look to improve mental health or wellbeing may look different in relation to the content and behavior change techniques used, compared to those which focus specifically on improving lifestyle risk behaviors (Hollis et al., 2017; Martin et al., 2013). Previous research has shown that there is a 'clustering effect', where adolescents who engage in multiple lifestyle risk behaviors have a higher prevalence of mental health symptoms (Champion et al., 2018; Gardner et al., 2023). Today's adolescents have reported that issues that affect their ability to maintain a healthy lifestyle are broad, but also interconnected and need to be considered in a multidimensional context (Valanju et al., 2022). Preventive interventions which target both the risk and protective factors for chronic diseases and mental health will also be cost-effective. Hence, there is likely to be considerable benefits when designing future digital health interventions by shifting the focus and aiming to improve lifestyle risk behaviors which are shared risk and protective factors for future development of chronic diseases and mental health (Carbone, 2020; Gardner et al., 2023).

There were vast differences in the digital health delivery method across the 17 included studies, with a combination of five different formats used. The differences in delivery methods for digital health interventions make it unclear which method is most effective. Adolescents are digital natives and use technology daily (Moreno et al., 2022), however, to effectively engage with digital health interventions they must have high digital health literacy skills. Previous research has shown that adolescents often rate their digital health literacy higher than demonstrated (Taba et al., 2022). Furthermore, it is essential that adolescents are engaged and satisfied with these interventions for them to be effective. Out of the 17 studies identified in this review, only five provided data on engagement with the intervention, which ranged broadly. Previous research has aimed to investigate adolescent engagement with digital health interventions across multiple areas (Aschbrenner et al., 2019; Thornton et al., 2022; Wong et al., 2020), however, all suggest that more rigorous RCTs are needed to understand engagement. Three strategies identified to increase adolescent engagement in digital health

Table 4 The Cochrane Collaboration for assessing risk of bias in included RCT's

Author, year, country	Domain 1: randomization		Domain 2: assignment to intervention		Domain 2: adhering to intervention		Domain 3: missing outcome data		Domain 4: outcome measurement		Domain 5: selective reporting		Overall risk of bias
	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	
Chan et al, 2022, Hong Kong	Low	Computer generated randomization table Allocation concealed Baseline differences between groups compatible with chance	Low	Participants aware of group assignment Assessors blinded to group assignment ITT analysis utilized	Some concerns	Participants aware of group assignment Assessors blinded to group assignment High level of dropout in one intervention arm	Low	Missing outcome data accounted for at each time point ITT analysis utilized	Low	Appropriate outcome measurement Comparable between groups Assessors blinded	Low	Pre-specified analysis plan All outcomes reported	Some concerns
Chen et al, 2018, USA	Low	Computer generated randomization table Allocation concealed No baseline differences between groups	Low	Participants unaware of group assignment Research team blinded to group assignment ITT analysis utilized	Low	Participants unaware of group assignment Research team blinded to group assignment	Low	Missing outcome data accounted for at each time point ITT analysis utilized	Low	Appropriate outcome measurement Comparable between groups Assessors blinded	Low	Pre-specified analysis plan All outcomes reported	Low

Table 4 (continued)

Author, year, country	Domain 1: randomization		Domain 2: assignment to intervention		Domain 2: adhering to intervention		Domain 3: missing outcome data		Domain 4: outcome measurement		Domain 5: selective reporting		Overall risk of bias
	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	
De Bruin et al, 2016, Netherlands	Some concerns	Concealed simple randomization using random number table Baseline differences between groups incompatible with chance	Low	Participants aware of group assignment Authors stated how treatment integrity was ensured Multilevel regression analysis used	Some concerns	Participants aware of group assignment Authors stated how treatment integrity was ensured	Low	Missing outcome data accounted for at each time point Multilevel regression analysis used	Low	Appropriate outcome measurement Comparable between groups	Low	Pre-specified analysis plan All outcomes reported	High
Eglisson et al., 2021, Iceland	Some concerns	Randomization using coin toss method NI on allocation concealment NI on baseline differences	Some concerns	Participants aware of group assignment Research team blinded to group assignment Multiple regression analysis used	Some concerns	Participants aware of group assignment Research team blinded to group assignment High level of dropout in intervention arm	Low	Missing outcome data accounted for at each time point Multiple regression analysis used	Low	Appropriate outcome measurement Comparable between groups Assessors blinded	Low	Pre-specified analysis plan All outcomes reported	High

Table 4 (continued)

Author, year, country	Domain 1: randomization		Domain 2: assignment to intervention		Domain 2: adhering to intervention		Domain 3: missing outcome data		Domain 4: outcome measurement		Domain 5: selective reporting		Overall risk of bias
	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	
Graham et al, 2021, USA	Low	Computer generated randomization table No baseline differences between groups	Low	Participants concealed from group assignment Research team concealed from group assignment ITT analysis utilized	Low	Participants concealed from group assignment Research team concealed from group assignment	Low	Missing outcome data accounted for at each time point ITT analysis utilized	Low	Appropriate outcome measurement Comparable between groups Assessors blinded	Low	Pre-specified analysis plan All outcomes reported	Low
Jones et al, 2008, USA	Some concerns	Randomization sequence generated in SPSS NI on allocation concealment No baseline differences between groups	Low	Participants aware of group assignment Assessors blinded to group assignment ITT analysis utilized	Some concerns	Participants aware of group assignment Some non-adherences to intervention reported Assessors blinded to group assignment ITT analysis utilized	Low	ITT analysis utilized No differences between completers vs non completers	Low	Appropriate outcome measurement Comparable between groups Assessors blinded	Some concerns	Only results from completer analysis are included as no difference between ITT analyses	High

Table 4 (continued)

Author, year, country	Domain 1: randomization		Domain 2: assignment to intervention		Domain 2: adhering to intervention		Domain 3: missing outcome data		Domain 4: outcome measurement		Domain 5: selective reporting		Overall risk of bias
	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	
Kose et al., 2020, Turkey	Low	Computer generated randomization table No baseline differences between groups	High	Participants single-blindly assigned to groups Deviations to trial context No ITT analysis	High	Participants single-blindly assigned to groups No data provided on adherence to intervention Intervention group outnumbered control	High	Number lost to follow-up not accounted for/no appropriate analysis	Low	Appropriate outcome measurement Comparable between groups	Some concerns	No pre-specified analysis plan Various statistical analyses used, all eligible results reported	High
Likhitweerawong et al, 2021, Thailand	Low	Computer generated randomization table Allocation concealed Baseline differences between groups compatible with chance	Low	Participants aware of group assignment Assessors blinded to group ITT analysis utilized	Some concerns	Participants aware of group assignment Assessors blinded to group Adherence to intervention noted Participants in control unintentionally received intervention	Low	Missing outcome data accounted for at each time point ITT analysis utilized	Low	Appropriate outcome measurement Comparable between groups Assessors blinded	Low	Pre-specified analysis plan All outcomes reported	Some concerns

Table 4 (continued)

Author, year, country	Domain 1: randomization		Domain 2: assignment to intervention		Domain 2: adhering to intervention		Domain 3: missing outcome data		Domain 4: outcome measurement		Domain 5: selective reporting		Overall risk of bias
	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	
Lopez et al, 2021, USA	Low	Block randomization utilized Investigators blinded to block size No baseline differences between groups	High	Participants aware of group assignment Unlikely protocol deviations No ITT analysis	High	Participants aware of group assignment Poor engagement with intervention	High	Number lost to follow-up not accounted for/no appropriate analysis	Low	Appropriate outcome measurement Comparable between groups	Low	Pre-specified analysis plan All outcomes reported	High
Richardson et al, 2021, USA	Low	Computer generated randomization table No baseline differences between groups	Low	Participants potentially aware/ clinicians aware of group assignment Unlikely protocol deviations ITT analysis utilized	Some concerns	Participants potentially aware of group assignment Authors stated how treatment integrity was ensured	Low	Missing outcome data accounted for at each time point ITT analysis utilized	Low	Appropriate outcome measurement Comparable between groups	Low	Pre-specified analysis plan All outcomes reported	Some concerns
Rodgers et al, 2018, USA	Low	Randomization schedule used Allocation concealed until after baseline No baseline differences between groups	High	Participants and researchers aware of group assignment NI on protocol deviations No ITT analysis	High	Participants and researchers aware of group assignment No data provided on adherence to intervention	High	Total scores calculated using mean substitution for missing data	Low	Appropriate outcome measurement Comparable between groups	Low	Pre-specified analysis plan All outcomes reported	High

Table 4 (continued)

Author, year, country	Domain 1: randomization		Domain 2: assignment to intervention		Domain 2: adhering to intervention		Domain 3: missing outcome data		Domain 4: outcome measurement		Domain 5: selective reporting		Overall risk of bias
	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	
Slootmaker et al, 2010, Netherlands	Low	Sealed envelopes used for randomization Minimal baseline differences between groups	Low	Participants unaware of group assignment Unlikely protocol deviations ITT analysis utilized	Low	Participants unaware of group assignment Process measures reported	Low	Missing outcome data accounted for at each time point ITT analysis utilized	Low	Appropriate outcome measurement Comparable between groups	Low	Pre-specified analysis plan All outcomes reported	Low
Thompson et al, 2016, USA	Low	Computer generated randomization table No baseline differences between groups	Some concerns	Participants and researchers aware of group assignment Unlikely protocol deviations No ITT analysis	Low	Participants and researchers aware of group assignment Technical issues reported and adherence documented	Low	Missing outcome data accounted for at each time point	Low	Appropriate outcome measurement Comparable between groups	Low	Pre-specified analysis plan Some data not presented (though stated as not significant)	Some concerns

ITT intention-to-treat, *NI* no information

Table 5 The Cochrane Collaboration for assessing risk of bias in included cluster RCT's

Author, year, country	Domain 1a: randomization		Domain 1b: identification or Recruitment		Domain 2: assignment to intervention		Domain 2: adhering to intervention		Domain 3: missing outcome data		Domain 4: outcome measurement		Domain 5: selective reporting		Overall risk of bias
	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	
Cremers et al, 2015, Netherlands	Some concerns	Computer generated randomization table NI on allocation concealment Baseline differences between groups	Low	All participants recruited before randomization Baseline imbalances compatible with chance	Low	Participants unaware they are in trial NI on trial personnel Multiple imputation of missing data	Some concerns	Participants unaware they are in trial NI on trial personnel No data provided on adherence to intervention	Low	Data available for all clusters Outcome data accounted for at each time point	Low	Appropriate outcome measurement Comparable between groups No influence of outcome assessors	Some concerns	Pre-specified analysis plan Not all outcome reported	High
Guo et al, 2014, Taiwan	Some concerns	NI on randomization process No baseline differences between groups	Low	All participants recruited before randomization Baseline imbalances compatible with chance	Low	Participants unaware they are in trial Trial personnel aware of group assignment Linear mixed model analysis	Some concerns	Participants unaware they are in trial No data provided on adherence to intervention	Low	Data available for all clusters Outcome data accounted for at each time point	Low	Appropriate outcome measurement Comparable between groups No influence of outcome assessors	Low	Pre-specified analysis plan All outcomes reported	High

Table 5 (continued)

Author, year, country	Domain 1a: randomization		Domain 1b: identification or Recruitment		Domain 2: assignment to intervention		Domain 2: adhering to intervention		Domain 3: missing outcome data		Domain 4: outcome measurement		Domain 5: selective reporting		Overall risk of bias
	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	Judgement	Evidence	
Lubans et al, 2012, Australia	Some concerns	Randomized on geographical location No baseline differences between groups	Low	All participants recruited before randomization No baseline imbalances	Some concerns	Participants unaware they are in trial Trial personnel aware of assignment ITT analysis used	Some concerns	Participants unaware they are in trial Trial personnel aware of assignment Adherence data presented	Low	Data available for all clusters Outcome data accounted for at each time point	Low	Appropriate outcome measurement Comparable between groups No influence of outcome assessors	Low	Prespecified analysis plan All outcomes reported	High
Vargas-Martínez et al., 2019, Spain	Some concerns	Randomized at school level Baseline differences between groups	Low	All participants recruited before randomization Baseline imbalances compatible with chance	Low	Participants unaware they are in trial NI on trial personnel Three regression models used for analysis	Low	Participants unaware they are in trial Adherence data presented	Low	Data available for all clusters Outcome data accounted for at each time point	Low	Appropriate outcome measurement Comparable between groups No influence of outcome assessors	Low	Prespecified analysis plan All outcomes reported	Some concerns

ITT intention to treat, *NI* no information

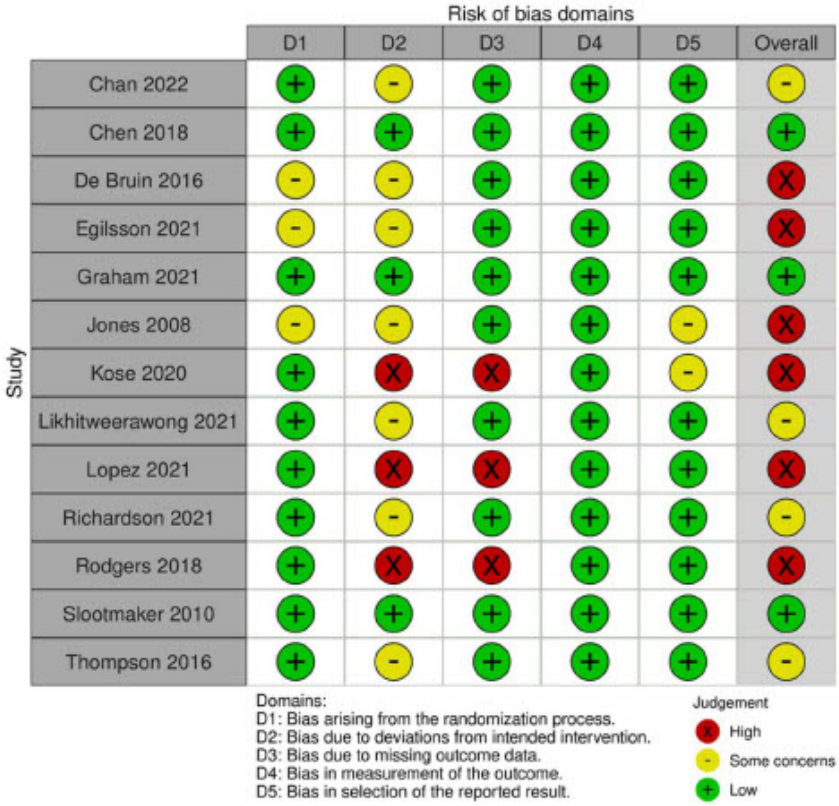


Fig. 4 RoB 2.0 quality assessment for randomized controlled trials

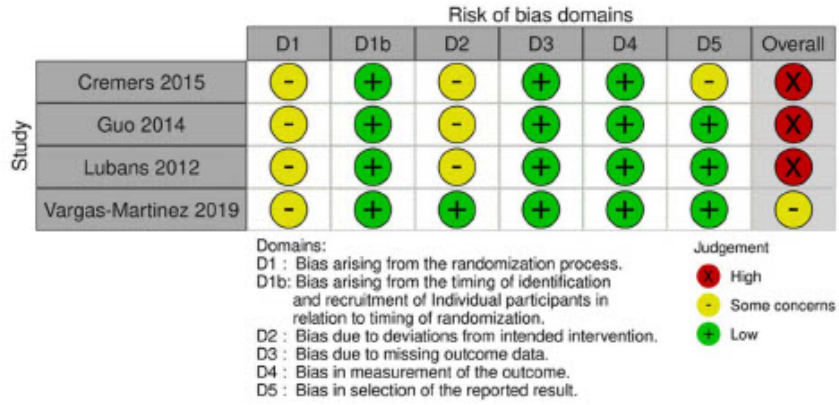


Fig. 5 RoB 2.0 quality assessment for cluster randomized controlled trials

interventions include personalization, just-in-time adaptation, and co-design with the end user (Partridge & Redfern, 2018). Only five of the 17 studies included in this review discussed the use of co-design of the intervention with adolescents. Engaging with adolescents throughout the entire research process is recognized in the WHO framework for developing and implementing digital health interventions for young people (World Health Organization, 2020). Lack of intervention co-design with adolescents potentially explains the broad range of engagement across studies and lack of significant results. Interestingly, three of the studies which reported co-designing the intervention with adolescents also reported data on satisfaction or retention, which was above 90% for two

studies (Richardson et al., 2021; Thompson et al., 2016). Future digital lifestyle interventions should ensure the use of co-design, with meaningful engagement of adolescents at every step, as well as determining the digital health literacy level of participants and tailoring the intervention to suit. This is critical to ensure that adolescent's knowledge and views are recognised and represented to enhance engagement, satisfaction, and intervention effectiveness.

This study is not without limitations. Firstly, due to the variety of studies and outcomes included, meta-analyses were based on a small number of studies and significant heterogeneity was present for most outcomes except depressive symptoms. Due to pooling of mental health and wellbeing outcomes, the variation in measurements should be considered when interpreting results. Further to this point, we were not able to adequately address our second aim due to variations in the data. We have provided a narrative synthesis of these variables where a quantitative analysis was inappropriate. Second, risk of bias was judged as high or had some concerns for many of the studies, which was mainly due to blinding of participants and outcome assessors. Third, the influence of publication bias must be considered. Grey literature was not searched in this review which may limit the number of included research studies, as negative study outcomes are less-likely to be published in peer-reviewed journals. Finally, very few studies reported a qualitative evaluation of the intervention to understand the barriers and enablers, which would enable a deeper understanding and interpretation of the usefulness of the interventions and allow planning for future research.

Conclusion

No previous research is available on the effectiveness of digital health interventions which target lifestyle risk behaviors on improving mental health or wellbeing among adolescents. This systematic review with meta-analyses revealed that digital health interventions targeting lifestyle risk behaviors amongst adolescents had small but non-significant positive effects on quality of life, anxiety and depressive symptoms at follow-up compared to usual care controls. Intervention satisfaction, engagement and adherence was poorly reported across included studies. Despite the shared nature of risk and protective factors for mental health and chronic diseases, this study highlights the scarcity of evaluation of mental health or wellbeing outcomes in digital health interventions targeting lifestyle risk behaviors among adolescents. It is recommended that future digital lifestyle health interventions consider a more holistic approach, focusing on the interplay between lifestyle risk behaviors and mental health and wellbeing.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s40894-023-00224-w.

Author Contributions RR designed the study protocol, designed and implemented the search strategy, screened and coded articles and extracted data, led the meta-analysis, interpreted the findings and write-up of results, drafted the initial manuscript; SSJ provided input to the study protocol, screened and coded articles and extracted data and revised the manuscript; AT screened and coded articles and extracted data and revised the manuscript; KH provided input to the study protocol, assisted with interpretation of findings and revised the manuscript; AS provided input to the study protocol and revised the manuscript; LAG provided input to the study protocol and revised the manuscript; KEC provided input to the study protocol and revised the manuscript; JR provided input to the study protocol and revised the manuscript; SRP provided input to the study protocol, provided input to coding of articles and extracted data, assisted with interpretation of findings and revised the manuscript. All authors read and approved the final manuscript.

Funding Open Access funding enabled and organized by CAUL and its Member Institutions.

Data availability All data generated or analyzed during this study are included in this published article. Search strategy for this study is available as Supplementary File 2. Data collection tables are available as Tables 1–3 and Supplementary File 3.

Declarations

Conflict of interest The authors report no conflict of interests.

Preregistration The review was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO; registration number: CRD42021247738). https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=247738

References

Aschbrenner, K. A., Naslund, J. A., Tomlinson, E. F., Kinney, A., Pratt, S. I., & Brunette, M. F. (2019). Adolescents' use of digital technologies and preferences for mobile health coaching in public mental health settings. *Frontiers in Public Health*. https://doi.org/10.3389/fpubh.2019.00178

Bantjes, J. (2022). Digital solutions to promote adolescent mental health: Opportunities and challenges for research and practice. *PLOS Medicine, 19*(5), e1004008. https://doi.org/10.1371/journal.pmed.1004008

Barbaresko, J., Rienks, J., & Nöthlings, U. (2018). Lifestyle indices and cardiovascular disease risk: A meta-analysis. *American Journal*

of Preventive Medicine, 55(4), 555–564. https://doi.org/10.1016/j.amepre.2018.04.046

Bergin, A. D., Vallejos, E. P., Davies, E. B., Daley, D., Ford, T., Harold, G., Kidner, M., Long, Y., Merry, S., Moriss, R., Sayal, K., Sonuga-Barke, E., Robinson, J., Torous, J., & Hollis, C. (2020). Preventive digital mental health interventions for children and young people: a review of the design and reporting of research. *npj Digital Medicine, 3*(1), 133–35. https://doi.org/10.1038/s41746-020-00339-7

Carbone, S. (2020). *Evidence review: The primary prevention of mental health conditions*. Victorian Health Promotion Foundation.

Champion, K. E., Mather, M., Spring, B., Kay-Lambkin, F., Teesson, M., & Newton, N. C. (2018). Clustering of multiple risk behaviors among a sample of 18-year-old Australians and associations with mental health outcomes: A latent class analysis. *Frontiers in Public Health, 6*, 135. https://doi.org/10.3389/fpubh.2018.00135

Champion, K. E., Parmenter, B., McGowan, C., Spring, B., Wafford, Q. E., Gardner, L. A., Thornton, L., McBride, N., Carrett, E. L., Teesson, M., & Newton, N. C. (2019). Effectiveness of school-based eHealth interventions to prevent multiple lifestyle risk behaviours among adolescents: A systematic review and meta-analysis. *Lancet Digit Health, 1*(5), e206–e221. https://doi.org/10.1016/s2589-7500(19)30088-3

Chan, N. Y., Lam, S. P., Zhang, J., Chan, J. W. Y., Yu, M. M. W., Suh, S., Yang, C.-M., Okajima, I., Martin, A., Wing, Y. K., & Li, S. X. (2022). Efficacy of email-delivered versus face-to-face group cognitive behavioral therapy for insomnia in youths: A randomized controlled trial. *Journal of Adolescent Health, 70*(5), 763–773.

Chatterjee, A., Prinz, A., Gerdes, M., & Martinez, S. (2021). Digital Interventions on healthy lifestyle management: systematic review. *Journal of Medical Internet Research, 23*(11), e26931. https://doi.org/10.2196/26931

Chen, J. L., Guedes, C. M., & Lung, A. E. (2018). Smartphone-based healthy weight management intervention for Chinese American adolescents: Short-term efficacy and factors associated with decreased weight. *Journal of Adolescent Health*. Retrieved from https://ezproxy.library.usyd.edu.au/login?url=http://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=cctr&AN=CN-01668678

Cremers, H. P., Mercken, L., Candel, M., de Vries, H., & Oenema, A. (2015). A web-based, computer-tailored smoking prevention program to prevent children from starting to smoke after transferring to secondary school: Randomized controlled trial. *Journal of Medical Internet Research*. https://doi.org/10.2196/jmir.3794

Cuijpers, P. (2022). Universal prevention of depression at schools: Dead end or challenging crossroad? *Evidence Based Mental Health, 25*(3), 96–98. https://doi.org/10.1136/ebmental-2022-300469

Dale, H., Brassington, L., & King, K. (2014). The impact of healthy lifestyle interventions on mental health and wellbeing: A systematic review. *Mental Health Review Journal, 19*(1), 1–26. https://doi.org/10.1108/MHRJ-05-2013-0016

De Bruin, E., Bogels, S., Oort, F., & Meijer, A. M. (2016). Improvements of adolescent psychopathology after insomnia treatment: Results from a randomized controlled trial over 1 year. *Journal of Sleep Research, 25*(Supplement 1), 91.

Egilsson, E., Bjarnason, R., & Njardvik, U. (2021). Usage and weekly attrition in a smartphone-based health behavior intervention for adolescents: Pilot randomized controlled trial. *JMIR Formative Research, 5*(2), e21432.

Farhat, T., Iannotti, R. J., & Simons-Morton, B. G. (2010). Overweight, obesity, youth, and health-risk behaviors. *American Journal of Preventive Medicine, 38*(3), 258–267. https://doi.org/10.1016/j.amepre.2009.10.038

Galani, C., & Schneider, H. (2007). Prevention and treatment of obesity with lifestyle interventions: Review and meta-analysis. *International Journal of Public Health, 52*, 348–359. https://doi.org/10.1007/s00038-007-7015-8

Gardner, L. A., Champion, K. E., Chapman, C., Newton, N. C., Slade, T., Smout, S., Teesson, M., & Sunderland, M. (2023). Multiple lifestyle risk behaviours and hierarchical dimensions of psychopathology in 6640 Australian adolescents. *Australian & New Zealand Journal of Psychiatry*. https://doi.org/10.1177/00048674221080406

Graham, A. L., Amato, M. S., Cha, S., Jacobs, M. A., Bottcher, M. M., & Papandonatos, G. D. (2021). Effectiveness of a vaping cessation text message program among young adult e-cigarette users a randomized clinical trial. *JAMA Internal Medicine*. https://doi.org/10.1001/jamainternmed.2021.1793

Guo, J. L., Liao, J. Y., Chang, L. C., Wu, H. L., & Huang, C. M. (2014). The effectiveness of an integrated multicomponent program for adolescent smoking cessation in Taiwan. *Addictive Behaviors, 39*(10), 1491–1499. https://doi.org/10.1016/j.addbeh.2014.05.009

Hollis, C., Falconer, C. J., Martin, J. L., Whittington, C., Stockton, S., Glazebrook, C., & Davies, E. B. (2017). Annual research review: Digital health interventions for children and young people with mental health problems—a systematic and meta-review. *Journal of Child Psychology and Psychiatry, 58*(4), 474–503. https://doi.org/10.1111/jcpp.12663

Javed, S., Usmani, S., Sarfraz, Z., Sarfraz, A., Hanif, A., Firoz, A., Baig, R., Sharath, M., Walia, N., Chérrez-Ojeda, I., & Ahmed, S. (2022). A scoping review of vaping, e-cigarettes and mental health impact: Depression and suicidality. *Journal of Community Hospital Internal Medicine Perspectives, 12*(3), 33–39. https://doi.org/10.55729/2000-9666.1053

Johnston, B. C., Patrick, D. L., Devji, T., Maxwell, L. J., Bingham III, C. O., Beaton, D., Boers, M., Briel, M., Busse, J. W., Carrasco-Labra, A., Christensen, R., da Costa, B. R., El Dib, R., Lyddiatt. A., Ostelo, R. W., Shea, B., Singh, J., Terwee, C. B., Williamson, P. R., …, Guyatt, G. H. (2022). Patient-reported outcomes. In J. P. T. Higgins, J. Chandler, M. Cumpston, T. Li, M. J. Page, & V. A. Welch (Eds.), *Cochrane handbook for systematic reviews of interventions*. Retrieved from www.training.cochrane.org/handbook

Jones, M., Luce, K. H., Osborne, M. I., Taylor, K., Cunning, D., Doyle, A. C., Wilfley, D. E., & Taylor, C. B. (2008). Randomized, controlled trial of an Internet-facilitated intervention for reducing binge eating and overweight in adolescents. *Pediatrics, 121*(3), 453–462. https://doi.org/10.1542/peds.2007-1173

Kang, M. R. F., Sanci, L., Steinbeck, K., Jan, S., Hawke, C., Luscombe, G., Kong, M., & Usherwood, T. (2018). *Access 3: Young people and the health system in the digital age—final research report*. Retrieved from https://www.health.nsw.gov.au/kidsfamilies/youth/Pages/access-study.aspx

Kessler, R. C., Angermeyer, M., Anthony, J. C., De Graaf, R., Demyttenaere, K., Gasquet, I., Girolamo, G. D., Gluzman, S., Gureje O., Haro J. M., Kawakami, N., Karam, A., Levinson, D., Mora, M. E. M., Browne, M. A. O., Posada-Villa, J., Stein, D. J., Tsang, C. H. A., … Ustün, T. B. (2007). Lifetime prevalence and age-of-onset distributions of mental disorders in the World Health Organization's World Mental Health Survey Initiative. *World Psychiatry, 6*(3), 168–176.

Kinghorn, A., Shanaube, K., Toska, E., Cluver, L., & Bekker, L.-G. (2018). Defining adolescence: Priorities from a global health perspective. *The Lancet Child & Adolescent Health, 2*(5), e10. https://doi.org/10.1016/S2352-4642(18)30096-8

Köse, S., & Yıldız, S. (2021). Motivational support programme to enhance health and well-being and promote weight loss in overweight and obese adolescents: A randomized controlled trial in Turkey. *International Journal of Nursing Practice, 27*(1), 1–10. https://doi.org/10.1111/ijn.12878

Kouvari, M., Karipidou, M., Tsiampalis, T., Mamalaki, E., Poulimeneas, D., Bathrellou, E., Panagiotakos, D., & Yannakoulia, M. (2022). Digital health interventions for weight management in children and adolescents: Systematic review and meta-analysis. *J Med Internet Res, 24*(2), e30675. https://doi.org/10.2196/30675

Lawrence, D., Johnson, S. E., Mitrou, F., Lawn, S., & Sawyer, M. (2022). Tobacco smoking and mental disorders in Australian adolescents. *Australian & New Zealand Journal of Psychiatry, 56*(2), 164–177. https://doi.org/10.1177/00048674211009617

Likhitweerawong, N., Boonchooduang, N., Kittisakmontri, K., Chonchaiya, W., & Louthrenoo, O. (2021). Effectiveness of mobile application on changing weight, healthy eating habits, and quality of life in children and adolescents with obesity: A randomized controlled trial. *BMC Pediatrics, 21*(1), 499.

Lima, F., Sims, S., & O'Donnell, M. (2020). Harmful drinking is associated with mental health conditions and other risk behaviours in Australian young people. *Australian and New Zealand Journal of Public Health, 44*(3), 201–207. https://doi.org/10.1111/1753-6405.12978

Lopez, K. E., Salvy, S.-J., Fink, C., Werner, J., Wee, C. P., Hegedus, E., Gonzalez, J., Fox, D. S., & Vidmar, A. P. (2021). Executive functioning, depressive symptoms, and intervention engagement in a sample of adolescents enrolled in a weight management program. *Childhood Obesity, 17*(4), 281–290. https://doi.org/10.1089/chi.2020.0334

Lubans, D. R., Morgan, P. J., Callister, R., Collins, C. E., & Plotnikoff, R. C. (2010). Exploring the mechanisms of physical activity and dietary behavior change in the Program X intervention for adolescents. *Journal of Adolescent Health, 47*(1), 83–91. https://doi.org/10.1016/j.jadohealth.2009.12.015

Lubans, D. R., Morgan, P. J., Okely, A. D., Dewar, D., Collins, C. E., Batterham, M., Callister, R., & Plotnikoff, R. C. (2012). Preventing obesity among adolescent girls. *Archives of Pediatrics & Adolescent Medicine, 166*(9), 821–827. https://doi.org/10.1001/archpediatrics.2012.41

Martin, J., Chater, A., & Lorencatto, F. (2013). Effective behaviour change techniques in the prevention and management of childhood obesity. *International Journal of Obesity, 37*(10), 1287–1294. https://doi.org/10.1038/ijo.2013.107

McCall, H. C., Hadjistavropoulos, H. D., & Loutzenhiser, L. (2021). Reconsidering the ethics of exclusion criteria in research on digital mental health interventions. *Ethics & Behavior, 31*(3), 171–180. https://doi.org/10.1080/10508422.2019.1684295

Melissa Bujtor, S. T. (2019). Associations between combined modifiable lifestyle behaviours and mental health in children and adolescents: a systematic review. Retrieved from https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=112748

Montero-Marin, J., Allwood, M., Ball, S., Crane, C., De Wilde, K., Hinze, V., Jones, B., Lord, L., Nuthall, E., Raja, A., Taylor, L., Tudor, K., Blakemore, S.-J., Byford, S., Dalgleish, T., Ford, T., Greenberg, M. T., Ukoumunne, O. C., Williams, J. M. G., & Kuyken, W. (2022). School-based mindfulness training in early adolescence: What works, for whom and how in the MYRIAD trial? *Evidence Based Mental Health, 25*(3), 117–124. https://doi.org/10.1136/ebmental-2022-300439

Moreno, M. A., Binger, K., Zhao, Q., Eickhoff, J., Minich, M., & Uhls, Y. T. (2022). Digital technology and media use by adolescents: Latent class analysis. *JMIR Pediatrics and Parenting, 5*(2), e35540. https://doi.org/10.2196/35540

O'Neil, A., Quirk, S. E., Housden, S., Brennan, S. L., Williams, L. J., Pasco, J. A., Berk, M., & Jacka, F. N. (2014). Relationship between diet and mental health in children and adolescents: A systematic review. *American Journal of Public Health, 104*(10), e31-42. https://doi.org/10.2105/ajph.2014.302110

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ, 372*, n71. https://doi.org/10.1136/bmj.n71

Partridge, S. R., & Redfern, J. (2018). Strategies to engage adolescents in digital health interventions for obesity prevention and management. *Healthcare (Basel)*. https://doi.org/10.3390/healthcare6030070

Racine, N., McArthur, B. A., Cooke, J. E., Eirich, R., Zhu, J., & Madigan, S. (2021). Global prevalence of depressive and anxiety symptoms in children and adolescents during COVID-19: A meta-analysis. *JAMA Pediatrics, 175*(11), 1142–1150. https://doi.org/10.1001/jamapediatrics.2021.2482

Richardson, L., Parker, E. O., Zhou, C., Kientz, J., Ozer, E., & McCarty, C. (2021). Electronic health risk behavior screening with integrated feedback among adolescents in primary care: Randomized controlled trial. *Journal of Medical Internet Research, 23*(3), e24135. https://doi.org/10.2196/24135

Rodgers, R. F., Donovan, E., Cousineau, T., Yates, K., McGowan, K., Cook, E., Lowy, A. S., & Franko, D. L. (2018). BodiMojo: Efficacy of a mobile-based intervention in improving body image and self-compassion among adolescents. *Journal of Youth & Adolescence, 47*(7), 1363–1372. https://doi.org/10.1007/s10964-017-0804-3

Rodriguez-Ayllon, M., Cadenas-Sánchez, C., Estévez-López, F., Muñoz, N. E., Mora-Gonzalez, J., Migueles, J. H., Molina-García, P., Henriksson, H., Mena-Molina, A., Martínez-Vizcaíno, V., Catena, A., Löf, M., Erickson, K. I., Lubans, D. R., Ortega, F. B., & Esteban-Cornejo, I. (2019). Role of physical activity and sedentary behavior in the mental health of preschoolers, children and adolescents: A systematic review and meta-analysis. *Sports Medicine (Auckland, N. Z.), 49*(9), 1383–1410. https://doi.org/10.1007/s40279-019-01099-5

Rose, T., Barker, M., Maria Jacob, C., Morrison, L., Lawrence, W., Strömmer, S., Vogel, C., Woods-Townsend, K., Farrell, D., Inskip, H., & Baird, J. (2017). A systematic review of digital interventions for improving the diet and physical activity behaviors of adolescents. *Journal of Adolescent Health, 61*(6), 669–677. https://doi.org/10.1016/j.jadohealth.2017.05.024

Sampasa-Kanyinga, H., Colman, I., Goldfield, G. S., Janssen, I., Wang, J., Podinic, I., Tremblay, M. S., Saunders, T. J., Sampson, M., & Chaput, J.-P. (2020). Combinations of physical activity, sedentary time, and sleep duration and their associations with depressive symptoms and other mental health problems in children and adolescents: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 17*(1), 72. https://doi.org/10.1186/s12966-020-00976-x

Slootmaker, S. M., Chinapaw, M. J., Seidell, J. C., van Mechelen, W., & Schuit, A. J. (2010). Accelerometers and Internet for physical activity promotion in youth? Feasibility and effectiveness of a minimal intervention. *Preventive Medicine, 51*(1), 31–36.

Sterne, J. A. C., Savović, J., Page, M. J., Elbers, R. G., Blencowe, N. S., Boutron, I., Cates, C. J., Cheng, H-Y., Corbett, M. S., Eldridge, S. M., Emberson, J. R., Hernán, M. A., Hopewell, S., Hróbjartsson, A., Junqueria, D. R., Jüni, P., Kirkham, J. J., Lasserson, T., Li, T., … Higgins, J. P. T. (2019). RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ, 366*, 14898. https://doi.org/10.1136/bmj.l4898

Sundar, T. K. B., Løndal, K., Riiser, K., Lagerløv, P., Glavin, K., & Helseth, S. (2019). Adolescents with overweight or obesity: A qualitative study of participation in an internet-based program to increase physical activity. *SAGE Open Nursing, 5*, 2377960819884786. https://doi.org/10.1177/2377960819884786

Taba, M., Allen, T. B., Caldwell, P. H. Y., Skinner, S. R., Kang, M., McCaffery, K., & Scott, K. M. (2022). Adolescents' self-efficacy

and digital health literacy: A cross-sectional mixed methods study. *BMC Public Health, 22*(1), 1223. https://doi.org/10.1186/s12889-022-13599-7

Thompson, D., Cantu, D., Ramirez, B., Cullen, K. W., Baranowski, T., Mendoza, J., Anderson, B., Jago, R., Rodgers, W., & Liu, Y. (2016). Texting to increase adolescent physical activity: Feasibility assessment. *American Journal of Health Behavior, 40*(4), 472–483. https://doi.org/10.5993/ajhb.40.4.9

Thornton, L., Brown, H. M., Osman, B., Stewart, C., Whife, J., Champion, K. E., Gardner, L. A., McBride, N., Allsop, S., Spring, B., & Teesson, M. (2022). Factors associated with adolescents' engagement with a Healthy Lifestyles app. *Procedia Computer Science, 206*, 56–67. https://doi.org/10.1016/j.procs.2022.09.085

Valanju, R., Barani, M., Mautner, D., Al Hadaya, I., Cross, A., Gunawardana, M., Lambie, A., McMahon, E., Narula, A., Ren, B., Rose, D., Sharda, A., Sinnett, A., Tanvir, A., Tran, H., Yan, F., Mandoh, M., Cheng, H. L., Mihrshahi, S., … Partridge, S. R. (2022). Youth perspective on chronic disease prevention. *The Lancet Child & Adolescent Health, 6*(7), 456–458. https://doi.org/10.1016/S2352-4642(22)00131-6

Vargas-Martínez, A. M., Trapero-Bertran, M., Lima-Serrano, M., Anokye, N., Pokhrel, S., & Mora, T. (2019). Measuring the effects on quality of life and alcohol consumption of a program to reduce binge drinking in Spanish adolescents. *Drug and Alcohol Dependence*. https://doi.org/10.1016/j.drugalcdep.2019.107597

Werner-Seidler, A., Huckvale, K., Larsen, M. E., Calear, A. L., Maston, K., Johnston, L., Torok, M., O-Dea, B., Batterham, P. J., Schweizer, S., Skinner, S. R., Steinbeck, K., Ratcliffe, J., Oei, J-L., Patton, G., Wong, I., Beames, J., Wong, Q. J. J., … Christensen, H. (2020). A trial protocol for the effectiveness of digital interventions for preventing depression in adolescents: The Future Proofing Study. *Trials, 21*(1), 2. https://doi.org/10.1186/s13063-019-3901-7

Wong, C. A., Madanay, F., Ozer, E. M., Harris, S. K., Moore, M., Master, S. O., Moreno, M., & Weitzman, E. R. (2020). Digital health technology to enhance adolescent and young adult clinical preventive services: Affordances and challenges. *Journal of Adolescent Health, 67*(2), S24–S33. https://doi.org/10.1016/j.jadohealth.2019.10.018

Woo, S., & Park, K. H. (2020). Motivating children and adolescents in obesity treatment. *Journal of Obesity & Metabolic Syndrome, 29*(4), 260–269. https://doi.org/10.7570/jomes20026

World Health Organization. (2014). *Health for the World's Adolescents: A second chance in the second decade*. World Health Organization. Retrieved from https://apps.who.int/adolescent/second-decade/

World Health Organization. (2020). *Youth-centred digital health interventions: a framework for planning, developing and implementing solutions with and for young people*. World Health Organization. Retrieved from https://www.who.int/publications/i/item/9789240011717

World Health Organization. (2021). Adolescent mental health. World Health Organization. Retrieved from https://www.who.int/news-room/fact-sheets/detail/adolescent-mental-health#:~:text=Globally%2C%20one%20in%20seven%2010,illness%20and%20disability%20among%20adolescents.

World Health Organization. (2022). Adolescent and young adult health. World Health Organization. Retrieved from https://www.who.int/news-room/fact-sheets/detail/adolescents-health-risks-and-solutions

Appendix 1: PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	1-2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	3-4
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	4
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	4-5
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	5
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Appendix 2
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	5-6
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	6
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	4-6
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	6-7
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	7
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	6
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	6
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	6
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	6
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	6
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	6
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	6-7
Reporting bias	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	6-7

Section and Topic	Item #	Checklist item	Location where item is reported
assessment			
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	N/A
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	7, Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	N/A
Study characteristics	17	Cite each included study and present its characteristics.	7-8, Table 1, 2
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	11
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Appendix 3
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	8-11
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	8-11, Figure 2
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	8-11, Figure 2
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	8-11, Figure 3
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	12
	23b	Discuss any limitations of the evidence included in the review.	12
	23c	Discuss any limitations of the review processes used.	14
	23d	Discuss implications of the results for practice, policy, and future research.	12-14
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	4
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	4
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	6-7
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	7, 16
Competing	26	Declare any competing interests of review authors.	16

Section and Topic	Item #	Checklist item	Location where item is reported
interests			
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	16

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71
For more information, visit: http://www.prisma-statement.org/

Appendix 2: Search strategy for Pre-Medline, Medline, Embase, Cochrane Cochrane Central Register of Controlled Trials (CENTRAL), AMED (via OvidSP 1946-present)

1	Telemedicine.mp. or Telemedicine/
2	e-health.mp.
3	ehealth.mp.
4	electronic health.mp.
5	digital health.mp.
6	mobile health.mp.
7	mhealth.mp.
8	m-health.mp.
9	Cell Phone/ or Cell Phone*.mp.
10	cellphone*.mp.
11	mobile phone*.mp.
12	Mobile Applications/ or mobile*.mp.
13	Text Messaging/ or text messag*.mp.
14	SMS.mp.
15	texting.mp.
16	Smartphone/ or smartphone*.mp.
17	smart phone*.mp.
18	world wide web.mp. or Internet/
19	online*.mp.
20	social media.mp. or Social Media/
21	(Facebook or WhatsApp or YouTube or skype or Instagram or twitter or Tumblr or Snapchat or Reddit or Myspace).mp.
22	email.mp. or Electronic Mail/
23	e-mail.mp.
24	(smartwatch* or smart watch*).mp.
25	wearable device*.mp. or Wearable Electronic Devices/
26	activity track*.mp.
27	Fitness Trackers/ or fitness track*.mp.
28	(e-portal* or eportal* or electronic portal).mp.
29	personal digital assistant.mp.
30	physical activit*.mp. or Exercise/

31	physical fitness.mp. or Physical Fitness/
32	diet.mp. or Diet/
33	nutrition.mp.
34	Food/ or "Diet, Food, and Nutrition"/ or food.mp.
35	Sleep/ or sleep.mp.
36	sedentary behavio?r.mp. or Sedentary Behavior/
37	screen time.mp. or Screen Time/
38	Smoking, Non-Tobacco Products/ or Tobacco/ or tobacco.mp.
39	smoking.mp. or Smoking/
40	alcohol.mp. or Alcohols/
41	drink*.mp. or Alcohol Drinking/
42	mental health.mp. or Mental Health/
43	(well-being or wellbeing).mp.
44	(self-esteem or self esteem).mp. or Self Concept/
45	(self-efficacy or self efficacy).mp. or Self Efficacy/
46	quality of life.mp. or "Quality of Life"/
47	Anxiety/ or anxiety.mp.
48	depress*.mp. or Depression/
49	self image.mp.
50	Resilience, Psychological/ or resilien*.mp.
51	stress.mp. or Stress, Psychological/
52	Adolescent/ or adolesce*.mp.
53	teen*.mp. or Adolescent Behavior/
54	young adult.mp. or Young Adult/
55	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29
56	30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51
57	52 or 53 or 54
58	55 and 56 and 57
59	control* trial*.mp. or Randomized Controlled Trials as Topic/
60	Clinical Trials as Topic/ or clinical trial*.mp.
61	59 or 60
62	58 and 61

63	limit 62 to yr="2005 -Current"

Appendix 3A: Data extracted for meta-analyses

Author, Year, Country	Questionnaire	Questionnaire domain	Post-intervention follow-up	'Most complex' intervention group (n)	Intervention group Mean (SD)	Control group (n)	Control group Mean (SD)
QoL (physical)							
Chen et al, 2018, USA	PedsQL	physical	6 months	23	84.69 (13.99)	17	77.83 (19.35)
Kose et al, 2020, Turkey	PedsQL	physical	6 months	43	78.63 (8.35)	37	71.06 (11.86)
Likhitweerawong et al, 2021, Thailand	PedsQL	physical	6 months	35	79.82 (17.67)	35	76.25 (16.66)
Vargas-Martinez et al, 2019, Spain	Health-related quality of life (EQ-5D-5L)	NA	4 months	742	0.944 (0.14)	505	0.94 (0.13)
QOL (psychosocial)							
Chen et al, 2018, USA	PedsQL	psychosocial	6 months	23	89.18 (8.75)	17	80.07 (14.49)
Kose et al, 2020, Turkey	PedsQL	psychosocial	6 months	43	79.16 (10.07)	37	69.31 (12.48)
Likhitweerawong et al, 2021, Thailand	PedsQL	psychosocial	6 months	35	79.82 (17.67)	35	76.25 (16.66)
Vargas-Martinez et al, 2019, Spain	Health-related quality of life (EQ-5D-5L)	NA	4 months	742	0.944 (0.14)	505	0.94 (0.13)
Depressive symptoms							
Chan et al, 2022, Hong Kong	HADS	Depression	8 weeks	45	5.8 (4.4)	45	6.9 (4.1)
Egilsson et al, 2021, Iceland	CDI	NA	6 weeks	20	73.4 (7.03)	21	71.85 (7.45)
Graham et al, 2021, USA	PHQ-2	NA	4 weeks	1304	1.98 (1.72)	1284	2.00 (1.77)
Jones et al, 2008, USA	CES-D 20	NA	16 weeks	52	11.29 (9.76)	53	13.22 (10.79)
Lopez et al, 2021, USA	CES-DC 10	NA	24 weeks	37	8.38 (5.22)	38	7.91 (5.41)
Anxiety							
Chan et al, 2022, Hong Kong	HADS	Anxiety	8 weeks	45	6.5 (3.4)	45	8.7 (3.6)
De Bruin et al, 2018, Netherlands	YSR	Anxiety problems	6 weeks	39	2.59 (1.82)	39	3.92 (2.07)

Egilsson et al, 2021, Iceland	MASC	NA	6 weeks	20	55.5 (13.1)	21	50.23 (13.16)
Graham et al, 2021, USA	GAD-2	NA	4 weeks	1304	2.41 (1.88)	1284	2.47 (1.88)

CDI: Children's Depression Inventory, CES-D: Center for Epidemiological Studies Depression Scale, CES-DC: enter for Epidemiological Studies Depression Scale of Children, EQ-5D-5L: EuroQol 5 Dimension 5 Level, GAD-2: Generalized Anxiety Disorder 2-item, HADS: Hospital Anxiety and Depression Scale, MASC: Multidimensional Anxiety Scale for Children, NA: Not Applicable, PedsQL: Pediatric Quality of Life , PHQ-2: Patient Health Questionnaire 2-item, SD: Standard Deviation

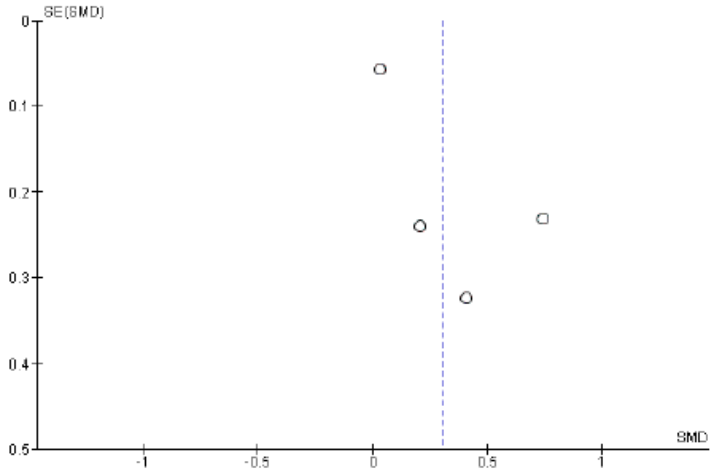
Appendix 3B: Data used for sensitivity analyses

Author, Year, Country	Questionnaire	Questionnaire domain	Post-intervention follow-up	'Most complex' intervention group (n)	Intervention group Mean (SD)	Control group (n)	Control group Mean (SD)
QoL (physical)							
Chen et al, 2018, USA	PedsQL	physical	6 months	23	84.69 (13.99)	17	77.83 (19.35)
Likhitweerawong et al, 2021, Thailand	PedsQL	physical	6 months	35	79.82 (17.67)	35	76.25 (16.66)
Vargas-Martinez et al, 2019, Spain	Health-related quality of life (EQ-5D-5L)	NA	4 months	742	0.944 (0.14)	505	0.94 (0.13)
QOL (psychosocial)							
Chen et al, 2018, USA	PedsQL	psychosocial	6 months	23	89.18 (8.75)	17	80.07 (14.49)
Likhitweerawong et al, 2021, Thailand	PedsQL	psychosocial	6 months	35	79.82 (17.67)	35	76.25 (16.66)
Vargas-Martinez et al, 2019, Spain	Health-related quality of life (EQ-5D-5L)	NA	4 months	742	0.944 (0.14)	505	0.94 (0.13)
Depressive symptoms							
Chan et al, 2022, Hong Kong	HADS	Depression	8 weeks	45	5.8 (4.4)	45	6.9 (4.1)
Graham et al, 2021, USA	PHQ-2	NA	4 weeks	1304	1.98 (1.72)	1284	2.00 (1.77)
Anxiety							
Chan et al, 2022, Hong Kong	HADS	Anxiety	8 weeks	45	6.5 (3.4)	45	8.7 (3.6)
Graham et al, 2021, USA	GAD-2	NA	4 weeks	1304	2.41 (1.88)	1284	2.47 (1.88)

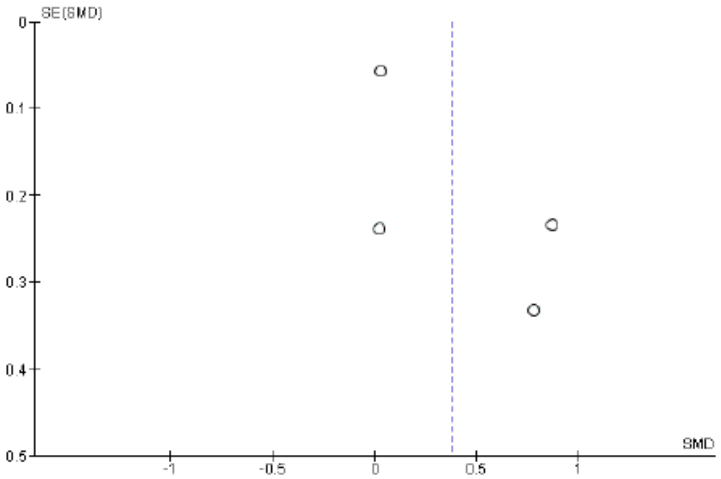
CES-D: Center for Epidemiological Studies Depression Scale, EQ-5D-5L: EuroQol 5 Dimension 5 Level, GAD-2: Generalized Anxiety Disorder 2-item, HADS: Hospital Anxiety and Depression Scale, NA: Not Applicable, PedsQL: Pediatric Quality of Life, PHQ-2: Patient Health Questionnaire 2-item, SD: Standard Deviation

Appendix 4: Funnel Plots of comparisons

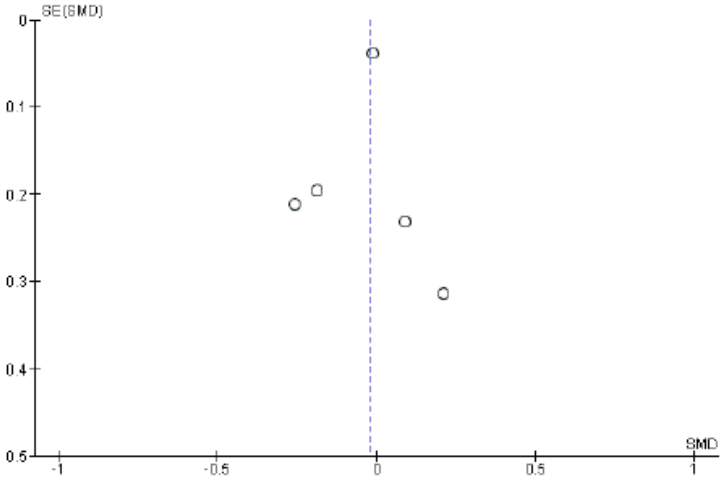
4.1 Funnel plot - QOL physical



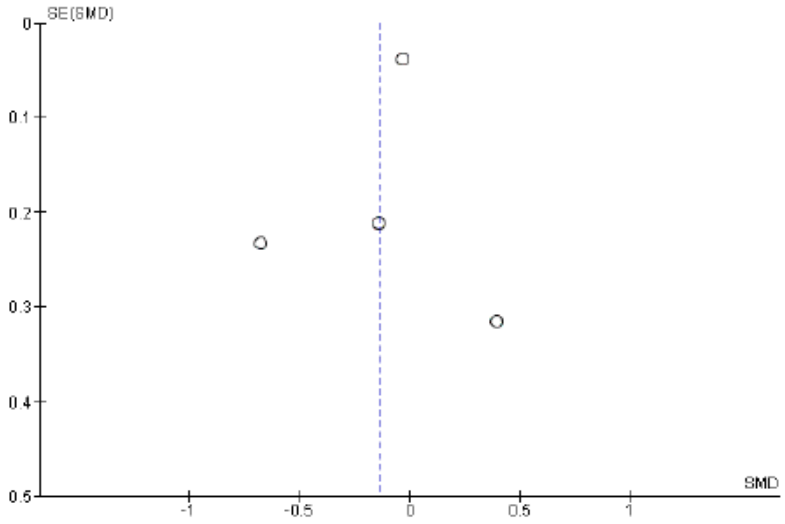
4.2 Funnel plot - QOL psychosocial



4.3 Funnel plot – Depressive symptoms



4.4 Funnel plot - Anxiety



SE: standard error, SMD: standardised mean difference

Chapter One

Introduction

Chapter Two

Systematic Review with Meta-Analysis

Chapter Three

Qualitative Study with Adolescents

HEALTH4ME

Chapter Four

Co-Design of Health4Me

Chapter Five

Health4Me RCT Protocol

Chapter Six

Health4Me Recruitment

Chapter Seven

Qualitative Study with Stakeholders

Chapter Eight

Discussion and Conclusions

CHAPTER THREE: Navigating the online world of lifestyle health information: qualitative study with adolescents

Preface to the Chapter

Chapter Two provided evidence that potential exists for digital health interventions that target lifestyle risk behaviours to improve mental health or wellbeing outcomes among adolescents due to the shared nature of risk and protective factors for mental health and chronic diseases. Of 17 included studies, only five evaluated adolescent engagement with the interventions (which ranged broadly among studies). This chapter (Chapter Three) presents the findings of a qualitative study to explore adolescents' perceptions of obtaining information or advice related to lifestyle health on contemporary digital platforms (websites, social media, smartphone apps), thereby addressing Aim 3 of this thesis. Ethics approvals and participant information and consent forms for this study are presented in Appendix B. This qualitative study has been peer-reviewed (submitted 23rd November 2021, resubmitted with corrections following reviewer comments 17th December 2021) and published (11th January 2022) in *JMIR Pediatrics and Parenting.* Authors contributions to this paper are outlined in the authorship attribution statement. Chapter Three was disseminated in the following ways:

Published peer reviewed manuscript

Raeside R, Jia SS, Redfern J, Partridge SR. Navigating the Online World of Lifestyle Health Information: Qualitative Study With Adolescents. *JMIR Pediatr Parent* 2022; 5(1):e35165 doi: 10.2196/35165.

Conference presentations

3. **Raeside R** et al (15-17/02/2022) Navigating the online world of lifestyle health information: an adolescent perspective. 10-min oral. University of Sydney Digital Health and Informatics Network, Digital Health Week 2022, Online.
4. **Raeside R** et al (15-18/05/2022) Navigating the online world of lifestyle health information: an adolescent perspective. Poster. International Union for Health Promotion and Education (IUHPE) 24th World Conference on Health Promotion, Online (Moved to online from in-person conference in Montreal, Canada after acceptance).

Author attribution statement

This statement is to stipulate the contribution of Rebecca Raeside in the preparation and submission of the following manuscript: ‘Navigating the Online World of Lifestyle Health Information: Qualitative Study With Adolescents’. The convention is that the author with the principal contribution to the study is the first author.

Rebecca Raeside, during her PhD candidature, assisted in developing the concept for the study, designed the data collection instruments, conducted the focus groups, analysed the data, interpreted the results, drafted the manuscript and subsequent revisions and coordinated submission for publication.

The individual roles of co-authors are listed below:

TASK	ROLE OF CO-AUTHORS
REFINING THE RESEARCH QUESTION	RR, SRP
DESIGNED DATA COLLECTION INSTRUMENTS	RR, SRP
CONDUCTED THE FOCUS GROUPS	RR, SSJ
TRANSCRIPTION OF FOCUS GROUP DATA	RR
ANALYSIS AND INTERPRETATION OF FOCUS GROUP DATA	RR, SSJ, SRP
DRAFTED MANUSCRIPT	RR
REVISION AND CRITICAL COMMENTS ON MANUSCRIPT	RR, SSJ, JR, SRP
MANUSCRIPT SUBMISSION	RR

Rebecca Raeside 26 Sept 2024

As supervisor for the candidature upon which this thesis is based, I can confirm that the author attribution statement above is correct.

Dr Stephanie Partridge 26 Sept 2024

Original Paper

Navigating the Online World of Lifestyle Health Information: Qualitative Study With Adolescents

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Abstract

Background: Adolescence is a critical life stage characterized by an interplay of biological, social, and environmental factors. Such factors influence lifestyle health-related trajectories, including dietary behaviors, physical activity levels, body weight, and sleep. Generation Z (born 1995-2015) is the most internet-dependent and technologically savvy generation in history with increasing rates of smartphone ownership across high- and low-income countries. Gaps exist in understanding what online platforms adolescents are using and barriers and facilitators of these platforms to seek lifestyle health information.

Objective: We evaluated adolescents' perceptions on the use of contemporary digital platforms (websites, social media platforms, smartphone apps) to seek lifestyle heath information or advice.

Methods: Virtual focus groups were held via Zoom teleconference between July 2021 and August 2021. Eligible participants were 13 years to 18 years old, were living in Australia, and had searched for online lifestyle health information in the previous 3 months. For this study, lifestyle health information referred to key behaviors and risk factors for chronic disease, namely, diet, physical activity, weight management, and sleep. Participants were recruited through an existing database of research participants and networks of the research team. Focus groups were analyzed using the framework approach, in which data are systematically searched to recognize patterns in the data and manage, analyze, and identify themes. Focus group audio files were transcribed verbatim and independently coded by 2 researchers (RR, SSJ). Through an iterative, reflexive process, a final coding matrix was agreed on by all researchers and used to thematically analyze the data.

Results: We held 5 focus groups (n=32; mean age: 16.3 [SD 1.4] years; 18/32, 56% female; 13/32, 41% spoke language other than English at home). Thematic analysis revealed participants searched for information both actively (eg, on Google or YouTube) and passively (eg, scrolling social media and using existing apps preloaded to their smartphone such as Apple Health, Samsung Health, or Google Fit apps). Participants identified that the most helpful information was well-presented in terms of aesthetic appeal and layout and came from a credible and reliable source (eg, any sponsorships disclosed), and they expressed the need for the information to be relatable. Mixed views were reported for the application of lifestyle health information found online. Some participants reported behavior change, while others noted that certain advice was hard to maintain and incorporate into their lifestyle.

Conclusions: This study highlights the abundance and complexity of lifestyle health information online for adolescents. Adolescents in the digital age seek access to information that is appealing, credible, relevant, and actionable for lifestyle health behaviors. To appeal to needs of adolescents, future interventions for adolescents relating to lifestyle health must consider co-design

methodological approaches. Furthermore, the regulation of lifestyle health information available online warrants further investigation.

(JMIR Pediatr Parent 2022;5(1):e35165) doi: 10.2196/35165

KEYWORDS

adolescents; chronic disease prevention; websites; social media; smartphone applications

Introduction

Today's adolescents, defined by the World Health Organization (WHO) as aged 10 years to 19 years, make up 16% of the global population [1]. Adolescence is a critical life stage during which a complex interplay of biological, social, and environmental factors determines the trajectory of lifestyle health behaviors into adulthood [2]. Lifestyle health behaviors and risk factors that are of great importance during adolescence are diet, physical activity, weight management, mental health, and sleep hygiene, as they are predictors of adverse health outcomes in adulthood, such as obesity and cardiovascular disease [3]. Globally, most adolescents do not meet diet or physical activity guidelines [4,5], and there has been a dramatic increase in the prevalence of overweight and obesity, jumping from 4% to over 18% in the last 40 years [6]. In Australia, very few adolescents meet guidelines for diet and physical activity [7,8], and adolescents do not get enough sleep on school nights [9]. Adolescence is an opportunistic window for establishing good lifestyle health behaviors [10]. Despite this, research priorities during adolescence are often focused on reducing other high-risk behaviors such as suicides, substance use, and sexual activity, with limited attention given to research that effectively harnesses digital technologies to target prevention of chronic diseases through lifestyle risk factor management [11,12].

Adolescents are known as "digital natives" as they have been born into a ubiquitous digital environment [13], which has grown exponentially in the last 20 years. In Australia, 94% of adolescents own a mobile phone, 95% are accessing the internet daily, and they use an average of 4 different social media platforms [14]. Previous research has shown that adolescents frequently turn to online sources such as internet websites and social media for lifestyle health information [15]. A national US survey found that adolescents are primarily looking at diet and fitness information online, with more trust placed on the internet than social media [16]. Furthermore, studies have explored how adolescents search for and appraise online health information and the extent to which they trust this information [17,18]. Furthermore, there is a constant expansion in the variety of digital platforms, including the uprise of contemporary platforms such as TikTok and Discord. As such, the current evidence base exploring the use of digital platforms to obtain information on lifestyle health behaviors is outdated. Contemporary digital platforms are a highly appealing and easily accessible way for adolescents to obtain lifestyle health information, given the increasing rates of smartphone ownership and their widespread use among adolescents for the pursuit of lifestyle health information.

As the digital health space is growing, gaps exist in our understanding of what contemporary digital platforms adolescents are using to seek this information and the barriers and facilitators of obtaining lifestyle health information on these platforms. Understanding the barriers and facilitators is crucial for governments, health organizations, researchers, and policy makers to be able to deliver appealing and effective lifestyle health promotion and support adolescents with management of chronic disease risk factors. Therefore, the aim of this study was to explore adolescent perceptions of obtaining information or advice related to lifestyle health from contemporary digital platforms.

Methods

This study adhered to the consolidated criteria for reporting qualitative research (COREQ) guidelines for reporting qualitative research (Multimedia Appendix 1) [19]. The study protocol was approved by the University of Sydney Human Research Ethics Committee (approval number 2020/613), and participants gave informed e-consent prior to participation.

Participants

Participants who were eligible to take part in the focus groups were aged 13 years to 18 years (inclusive). The WHO defines adolescents as 10 years to 19 years old; however, the range of 13 years to 18 years was selected to coincide with the age range of secondary education in Australia, which is a common setting for health promotion interventions by governments. Further eligibility criteria included living in Australia and having had accessed lifestyle health information online at least once in the previous 3 months. For this study, lifestyle health information referred to key behaviors and risk factors for chronic disease, namely, diet, physical activity, weight management, and sleep.

Recruitment

Participants were recruited through an existing database from a previous cross-sectional survey (Digitalize Study) [20] and known networks to the research team. The Digitalize Study was a cross-sectional survey to find out how young people (13-18 years old) search for lifestyle health information online including which digital platforms were most used, perceived helpfulness of information on digital platforms, helpfulness for positive behavior changes, and the quality of platforms' health information. Email invitations were sent with a link to the participant information sheet. All prospective participants read the participant information sheet online, provided informed e-consent, and were directed to an online survey to indicate demographic characteristics (age, gender, postcode, and language spoken at home) and how often they searched for lifestyle health information online in the previous 3 months. A 3-month time frame was chosen so that participants had up-to-date knowledge of lifestyle health information on these digital platforms. If participants had not accessed lifestyle health

information in the previous 3 months, they were not able to complete the survey and therefore were not contacted to take part in the focus groups. All eligible participants were contacted via text message to confirm date and time of focus group and were emailed the secure teleconference link.

Data Collection

A semistructured discussion guide was developed by the research team based on the outcomes of the Digitalize study [20] to further explore the perceptions of obtaining and using lifestyle health information online. To assess whether the focus group questions were easy to understand and acceptable, the interview guide was piloted with 2 youth advisors who currently work with the research team. The discussion guide is provided as supplementary material (Multimedia Appendix 2).

One researcher (RR) gave a brief overview of the discussion at the commencement of the focus groups. Participants were asked about where they accessed health information online (internet websites, social media platforms, and smartphone apps), why they used online sources, what type of content they found most engaging, and any potential changes to their lifestyle behaviors as a result of applying the information they obtained online. Based off their responses, the 2 platforms of most interest to the group were discussed in more detail. Questions explored how they searched for information on these online sources, what made these sources most and least appealing, and how they judged the reliability and usefulness of the information they found.

The focus groups were conducted by 2 researchers (RR, SSJ) via videoconferencing (Zoom Video Communications Inc, San Jose, CA) at a time convenient for participants. The focus groups were led by RR, and SSJ took detailed notes for each session. Each focus group took approximately 45 minutes to complete. RR has training and previous experience in conducting focus groups and semistructured interviews. Focus groups were recorded and transcribed verbatim into Microsoft Word (Version 16.54, Microsoft 365, Microsoft Corp, Redmond, WA) by RR. Recruitment of participants for focus groups ceased when thematic saturation was reached. Participants were not contacted for further focus groups or validation of transcripts. Each participant was provided with an Aus $20 (US $14.26) gift voucher for participation.

Data Analysis

The framework approach was used to analyze qualitative data [21], where data are systematically searched to recognize patterns in the data and manage, analyze, and identify themes. On completion of focus groups, RR and SSJ familiarized themselves with the data and undertook thematic analysis independently. RR and SSJ developed coding labels relevant to the research question and identified emergent themes. After systematically coding all the transcripts, the research team (RR, SSJ, and SRP) discussed themes that were further developed through an iterative and reflexive process. Consensus on final themes were developed and agreed on by all researchers. Qualitative data analysis was performed using NVivo 12 (12.2.0).

Results

Participant Characteristics

Focus group attendance was confirmed by 37 participants; 5 participants did not attend the focus groups without providing a reason, leaving a total sample of 32. Participant characteristics are reported in Table 1. Participants had a mean age of 16.3 years. From the study sample, 56% (18/32) of participants identified as female, with most participants residing in New South Wales (22/32, 69%). Two-fifths (13/32, 41%) spoke a language other than English at home. Participants varied in their frequency of accessing health information online with over one-third accessing health information online 1 to 2 times a month (12/32, 38%).

Table 1. Focus group participant characteristics (n=32).

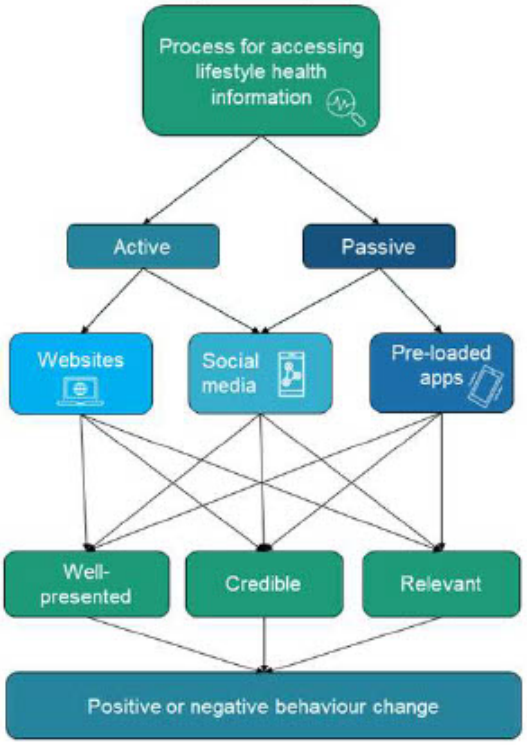
Participant characteristics	Results
Age (years), n (%)	
13-14	4 (13)
15-16	11 (34)
17-18	17 (53)
Age (years), mean (SD)	16.3 (1.4)
Gender, n (%)	
Male	13 (41)
Female	18 (56)
Prefer not to say	1 (3)
Residential state in Australia, n (%)	
New South Wales	22 (69)
Victoria	6 (19)
Western Australia	4 (13)
Language spoken at home, n (%)	
English only	19 (59)
>1 other languages spoken	13 (41)
Frequency of accessing lifestyle health information online, n (%)	
1-2 times a month	12 (38)
Once a week	7 (22)
A few times a week	8 (25)
Once a day	1 (3)
More than once a day	4 (13)

Themes

Overall Findings

Thematic analysis identified a complex interplay of 5 main themes relating to obtaining lifestyle health information across contemporary digital platforms (Figure 1). These 5 themes included the processes of accessing lifestyle health information online, the presentation of lifestyle health information online, the importance of credible and reliable information, having information relevant to adolescents, and perceived behavior changes from application of lifestyle health information found online. These themes emerged across the 3 digital platforms that were discussed in-depth (internet websites, social media platforms, and smartphone applications). Across different digital platforms, there were distinct similarities and differences, which are explored in detail in each theme in the next sections. Despite attempting to ascertain which type of lifestyle health content (ie, diet, physical activity, weight management, or sleep) would be most engaging to adolescents, all 5 focus groups did not have a clear emerging theme, with all aspects of lifestyle health discussed. The 5 emergent themes are discussed in detail in the following sections.

Figure 1. Conceptualization of emergent themes related to participants obtaining lifestyle health information across contemporary digital platforms.



Theme 1: Processes for Accessing Lifestyle Health Information Online

Adolescents identified internet websites and social media platforms as the top 2 sources for lifestyle health information online. However, they described the process for accessing information from these 2 sources differently. On digital platforms such as Google and YouTube, participants described actively searching for information of interest to them. Google searching for information was reported by most participants, who stated that they would only visit the first few websites that appeared in the search results. Websites that were commonly frequented by participants for health information were government-based websites and blogs. Some participants searched on YouTube for health information, especially relating to exercise and recipes.

> *I think that I would probably go and just do a google search honestly, and then whatever would come up there is what I would do. I don't think I'd refer to a specific website.* [FG2, 18M]
>
> *For me, it's like on Google, I usually get my information from the first like 10 or 8 websites or something, like the more backdated it is like in the second or third page, I feel like it would be less relevant to me.* [FG3, 17M]

Accessing health information on social media platforms was described differently as participants would passively receive information that appeared in their feed (from people who they chose to follow) or by scrolling through explore pages. Participants also identified that the information that they came across on social media platforms may have been targeted to them due to algorithms used by these platforms.

> *...it's not really like me actively searching up on Instagram; it's more me following like a few organizations and people like government, a few athletes, and physios and things like that.* [FG4, 16F]
>
> *I don't search that much for things cause things I [want to] know, they usually just come to me on my feed because you know TikTok and Instagram, they are really customized...* [FG5, 13F]

Smartphone applications were also identified by some participants as being used to access lifestyle health information. Similarly, for smartphone applications, participants mostly reported using applications that were already available on their smartphone (eg, Apple Health, Samsung Health, Google Fit) rather than searching app stores for new applications. When exploring reasons behind app usage, cost was a major factor, which supports this finding of using apps that are readily available to them.

> *I've [got to] say, I also use the standard health app on my phone, which is actually quite helpful cause I can track how much I exercise, how much I run, also other health-related things.* [FG4, 16F]
>
> *As I said, my phone already came with the app, so I didn't look for it.* [FG4, 17M]

> *I wouldn't spend money on an app to tell me all those things cause (sic) I can just find it on the internet.* [FG4, 16F]

Theme 2: Presentation of Lifestyle Health Information Online

Participants placed a large emphasis on the importance of how lifestyle health information is presented and organized for them online to be able to easily read and to interpret the information. This included the importance of white space and the use of dot points and subheadings on websites that would make them "easy to navigate" [FG4, 17F]. They reported that, if websites were not laid out logically or in an aesthetically appealing manner, they would often look elsewhere for the same information.

> *I'd say like organized well, like I don't want it to have all these clunks of information that is not actually relevant to what I'm looking for...and also like, you know, have lots of like white space on the page so it's easier to interpret and like dot points.* [FG1, 14M]

> *If the layout is really bad or like the words are all really close together, it just overwhelming to look at the website so I would be way more likely to click off.* [FG2, 18F]

Another subtheme that emerged was the importance of the quality of the content. This was reported both in terms of the actual information that was being presented and the production quality of videos or posts on social media. When information was presented in a way that appeared to be high quality and aesthetically appealing, most participants reported that they found it more credible. On social media, the production of posts or videos needed to be of good quality for them to follow that person and to "dig deeper" [FG5, 13F] into the account.

> *It's kind of a mix of both because if I like their content, I'll probably follow them, but if they have put like no effort into their page, it kind of like throws me off because I'm the type to like aesthetic-looking stuff.* [FG5, 14F]

> *I think the information they put out is important, but I think I'm less likely to actually follow them if the production is not as good as other people.* [FG5, 15M]

Theme 3: Credible and Reliable Lifestyle Health Information Online

Nearly all participants identified that they assessed whether the health information online was credible or reliable and this was achieved differently depending on the online source. For websites, participants reported looking if the information was referenced or included a bibliography. It was also recognized that participants mostly trusted government websites and well-known health organizations, but when it came to other websites, that they would "cross check" [FG1, 18F] to see whether there was a scientific backing to the information presented. By verifying this information with other sources, this demonstrates an awareness of where credible information originates.

> *I think it is based off your source, but most of the government stuff is pretty good.* [FG1, 17F]

> *I look for research papers, and if it's a government website or any sort of university and if it's a newsletter or something like that, then I try to check it twice with something else.* [FG3, 17M]

> *I think usually when you look at information, you can just kind of judge just by the way that they're putting forward the information and also just to cross check just Google to see whether their information matches up what other people are saying majority of the time.* [FG1, 18F]

On social media platforms, participants identified multiple ways they assessed whether what they saw was credible or reliable. First, participants emphasized the importance of having a person behind the account with their credentials clearly stated. Many participants also stated that if they had a blue tick, meaning that the account was verified, this would also increase their credibility. Furthermore, the follower count of the social media account was also seen to increase reliability, with more followers making them more reliable.

> *I think knowing more about the person behind it is useful because sometimes you will find information and you can tell that it is like really biased. It's information for sure, but it's what they want you to know, it's not really always true. So, if they could say like who they are and where they got the information, it would be a lot more trustworthy.* [FG2, 17F]

> *Well, if I see like a tick...like that blue tick, that they're like professional, I guess, and also like if I see that they have a lot of followers, I don't know sometimes, some organizations they have [been] verified by the NSW government and things like that.* [FG4, 16F]

Nearly all participants were acutely aware of sponsorships and advertising online. On social media, influencers are often paid to promote certain products or services. For most participants, if an account was constantly promoting one product, this would be a deterrent to trusting the information that they portrayed and was seen to be "off putting" [FG2, 18F]. Participants also understood that this was a way in which these accounts generated income.

> *I was just going to say that I think the content really matters and whether or not they're putting it out for the right reasons. I see, like sometimes, influencers, is that they are just kind of putting up information because they're getting paid to, you know, to advertise for those things.* [FG1, 18F]

> *I think if they are constantly advocating for like 1 idea or like 1 diet or, you know, 1 product or something like that, kind of puts you off because it shows that it's like, it's not genuine, it doesn't show other sides, and then you're kind of being biased.* [FG2, 17F]

> *If it's really pushing it and especially like Instagram and social media where it's just dedicated to that thing, to that endorsement, it's a little more off*

putting. But you know it's how it goes, they have to do it, so if I'm good with the content that they provide otherwise, then it's OK. [FG3, 17M]

Regarding advertising on websites, participants reported the type of advertisements were important. If the advertisement was unrelated to the website itself, then the website would be seen to be unreliable. However, having advertisements in general was seen to be acceptable, and when the information was referenced correctly, they would still consider the website to be reliable.

Definitely the type of ads, like if I see something that I'm like no that's not right, I'll probably get off the website as soon as like I see it. [FG5, 14F]

Just the ads doesn't really deduct from the website for me, cause for me, it's like if they cross reference it with at least one or two sites, like the first three sites no matter how un-user friendly they are if they say the same thing, then I just take that away from it. [FG3, 17M]

Another subtheme that was identified was that some participants assessed other people's comments on social media posts to see other opinions about whether the information that was presented was reliable. Likewise, when assessing mobile applications that they would potentially download, some participants looked at reviews on app stores to see whether other people thought the app was helpful for them.

I do go to the comments every single video or pretty much that I'm interested in to see what other people think about it, not for information purposes but sort of to see what other people's opinion on that particular post is. [FG5, 15M]

I would also definitely look at the reviews and not just what the reviews say but the amount of the reviews, how many people access the app, how many people say this or that, that kind of thing. [FG4, 16F]

Theme 4: Lifestyle Health Information Relevant to Adolescents

Most participants reported that searching for health information online was convenient. Participants reported online information as being easy to access, readily available, and regularly updated. Also, many participants reported that they accessed lifestyle health information from a variety of sources to compare the information themselves rather than seeing a health professional, which takes time and money and they may not provide the extent of information that can be found online.

Mainly because it's very accessible and just easy to access, very like fast, just search it up, and you basically have an answer. Um, also, I guess, you can find people who are going through similar situations, like same age group just people that are, who you can relate to, and I think that's generally where you can get a lot of advice from. [FG4, 16F]

I think because it's always like updated, whereas if you've got like an out-of-date leaflet or something, it might not be relevant. [FG1, 18F]

I definitely think it's easier to look it up online because then you just get a bigger range of answers as well like if you go to a doctor, they normally just give you one straight answer. [FG2, 18F]

When referring to social media specifically, many participants reported following accounts that were relatable. For an account to be relatable, they had to engage frequently with their followers in terms of posts or stories and have lifestyle health information and advice that would be easy to implement into their own lives. Also, it was recognized that the person behind the account was important in terms of relatability, due to a sense of familiarity. This did depend on the size of their existing following, with smaller accounts being favored as they were more likely to respond and engage with followers, whereas larger accounts were viewed as more reliable.

I'll generally follow accounts that like I can relate to so I can kind of use their posts in my own life. [FG2, 18F]

You can also find people who are in the same position as you like, for example people who are the same age...and it's really easy to see if their lifestyle, like you can take something from that so that's definitely been really helpful for me. [FG4, 16F]

I feel like you can, you know, you can build a better relationship and get familiar with what they do on social media and if they are also influencing you in fitness, etc, you follow that. [FG3, 17M]

Something like lifestyle, for example, I definitely go for the people who have less followers, if it's specifically like workout videos I tend to go for the big names like Chloe Ting or those sort of ones. [FG3, 17F]

Websites were often reported by participants as being too generalized and therefore were sometimes viewed as unrelatable and unhelpful for obtaining health information. Some participants identified that the information may not be specifically directed toward young people or in line with what they were wanting to achieve in terms of their personal goals. It was also identified that they had visited websites that provided a large variety of information but not enough detail; therefore, they were unable to make a judgement of whether that information would be relevant to them.

I think sort of just having information that is like more relevant to you. I know that a lot of the sort of diet information that I find on the internet, it's more sort of geared towards adults. [FG3, 17F]

For just general health and stuff, I find the government websites pretty lackluster, like they kind of just go through the motions and give the minimum information, so like, for what I'm interested in with training, the government websites aren't that great. [FG5, 15M]

Sometimes, it's just like you're not there for a really wordy essay, for example, like you guys are professionals but please make it understandable for us, you know, you're not trying to show off your skills,

> *you're trying to provide information that is useful and understandable.* [FG3, 16M]

Theme 5: Perceived Behavior Changes Based on Online Lifestyle Health Information

When regarding behavior change from online health information, participants reported a mixed variety of personal effectiveness. Some participants reported making changes based on information that they had seen online, including dietary changes such as restricting calories and physical activity changes including trying specific workouts that were not effective for them and subsequently viewed these behavioral changes negatively. As the behavioral changes were viewed undesirably, the changes were not sustained long term. Contrary to this, other participants reported making changes such as intermittent fasting and increasing total sleep time, which were viewed by participants as positive changes. It is important to note that, for some lifestyle changes, some of the participants viewed these positively, and others viewed them negatively, demonstrating the complexities of lifestyle health information and how individual preference also plays an important role. Furthermore, some participants outlined desire to make changes; however, the information that they found was "too hard to integrate" [FG4, 17F] or "doesn't last a very long time" [FG4, 16F].

> *I saw something online about like how much you should be eating...a day, and I severely restricted my like caloric intake, and I noticed, like, straight away that that in it had an impact.* [FG3, 17F]

> *When I found this out about intermittent fasting, it just sort of like suited me better than what the government guidelines tell you.* [FG1, 18F]

> *I googled how much sleep someone of my age should be getting, and it turns out it was a lot more...than what I was getting, so I try to go to bed a bit earlier and try to wake up a bit later each day.* [FG2, 14F]

Additional quotes for all themes are listed in Textbox 1.

Textbox 1. Quotes illustrating participants' experiences related to obtaining lifestyle health information online.

Theme 1. Process for accessing lifestyle health information online

- "I guess I wouldn't go to like Instagram or Facebook to look up health stuff but if it comes up on there, then I might like read it." [FG1, 17F]
- "I don't really like go on social media for like health info, but when I like scroll on Facebook and I see like news articles or like advice, I just click on the link if I'm interested, and if it's helpful, then I will just keep reading." [FG1, 18M]
- "I think that the majority of the information I find is accidental...so it's just stuff that I come across...on social media platforms. Most notably, Instagram because of the explore feature and like its content that is tailored to you." [FG3, 15F]
- "I feel like for us, like teenagers, there aren't as many people going on websites ... being regularly would more be like the accounts on Instagram." [FG5, 15M]
- "I guess for day-to-day info would be social media, but I would trace that if I actually get interested in it and go look at backup research on google or like a research facility who have done research on it." [FG3, 17M]
- "I think it's kind of a waste of money, like when you can get the exact same thing for free, and it's not like I really need it cause I'm like only 15." [FG5, 15M]
- "I use the health app as well, it kind of just tracks my sleep and steps and everything because I usually have my phone on me wherever I go." [FG5, 14F]

Theme 2. Presentation of lifestyle health information online

- "Some of the websites, they [are] just really convoluted and confusing, so if it's the first one that pops up but it's confusing, I will just like go to another one." [FG1, 18F]
- "I really like the pages that just kind of just sum all the points up like when they speak really, you know, sophisticated, it like, it allows you to trust what they are saying. I also like it when they sum it up at the end in just real simple English so it's straight to the point." [FG2, 16F]
- "If there's like...subheadings within the website or like the answer to it is straightforward rather than in like big paragraphs, because like I wouldn't be likely to read that and in dot points would be even easier." [FG3, 17M]
- "Yeah sorry, like headings and it being like scientific, so it is reliable but not um too scientific that we don't understand what is going on." [FG3, 18F]
- "A lot of the people who I'm like friends with, they would follow the person as well. And then like, just seeing their content, I kind of go through it, like if they're professional, you can [kind of] tell, and like they have it in their bios." [FG5, 14F]
- "The, um, production has to be eye catching for me to actually sort of dig a bit deeper into their account, but otherwise if the content is good, then I'll follow them." [FG5, 13F]
- "If they have consistently posted the same sort of content. Not necessarily about the same issue per se but like just if they have got a consistent amount of information like at least 30 posts, if it's something that I can sort of have a look through." [FG3, 15F]
- "It's definitely good if they do have a nice aesthetic side to it, but the content has to be like pretty clear and concise." [FG5, 13F]

Theme 3. Credible and reliable lifestyle health information online

- "Normally, if there is a verified tick or someone like known that's more trustworthy in that area, in health. So, it's like, if there is someone new with barely any followers...then it makes it less likely for you to follow that person." [FG3, 17M]
- "I just go back to the same ones if I find something useful or if it's helped me, I'll tend to go back to it because I know it's reliable and I've had a good experience with it." [FG3, 16M]
- "Usually, it's sort of based on the quality of the website because usually if it is based... and it looks nice they are sort of putting effort into it, and if it looks dodgy, then it's probably not going to be as credible." [FG3, 15F]
- "I just think the ah, the idea of having something government certified, and I think a clear distinction between advice and information." [FG4, 17M]
- "It's quite hard to sift through things that are unbiased, especially on the internet, especially with influencers as well when they are paid." [FG2, 18F]
- "I also agree with the sponsorship thing because when I found out some of the sponsorships, that's when I realized that some of this information it wasn't...like true, it was just because they were being paid to say that." [FG2, 14F]
- "Another thing that I do sometimes is before I download it, some people leave comments on App Store, which can actually end up being pretty helpful...and then if I think I don't want it anymore, I just don't download it." [FG5, 14F]

Theme 4. Lifestyle health information relevant to adolescents

- "I do it because a lot of the times, I feel like the health advice I'm trying to find is when a problem isn't that big of a deal, so I don't think it's worth going to someone like important." [FG2, 14F]
- "And it's also like having to see a person in real life is more daunting than actually searching up information for yourself." [FG3, 17M]

- "I would often go to an influencer even knowing that their information may not be as trustworthy just for the convenience aspect." [FG5, 15M]
- "I say when you talk about the engaging part, social media really takes the lead there because the type of video they make is captivating and the target audience can always be found." [FG3, 17M]
- "When it comes to diet information, I don't really find it helpful because um, because often the diet information is only helpful for like one specific type of group and it's like, it's hard to find something that is directed towards me." [FG2, 14F]
- "So, maybe if there's a government or some other organization released like a bunch of websites that they think would be really useful and then you could check them out and like maybe get feedback from young people to see which websites they like and things like that, that would definitely help." [FG4, 16F]

Theme 5. Perceived behavior changes based on online lifestyle health information

- "So, in high school, we were always told, oh you have to have 3 meals a day, and I feel like that didn't really suit my lifestyle, but then when I found this out about intermittent fasting, it just sort of like suited me better than what the government guidelines tell you." [FG1, 18F]
- "There is this documentary on YouTube called Dominon, and I watched probably only the first 20 minutes, and it's made me vegan for 2 years so far. It was like, yeah it showed you like a complete other different side to the information that's on the internet, and so yeah, it kind of did make a big change in my life." [FG2, 17F]
- "There was this craze about like skipping for fitness, and it was like... I tried it for a bit, and I didn't really have any results, so I stopped doing it." [FG3, 17M]
- "I saw some different posts and things like TikTok things on Instagram of bad side effects of drinking dairy, so it was one of the factors that made me not drink dairy anymore." [FG3, 15F]
- "With most of the things I see, it's either too hard to integrate for myself or I already do it, so I wouldn't say that I do anything specific that I've seen online." [FG4, 17F]

Discussion

Principal Findings

Overall, this qualitative study provides strong insight from adolescents into the barriers and facilitators of accessing and using lifestyle health information on contemporary digital platforms. To our knowledge, this study is among the first to explore adolescents' perceptions on their use of these contemporary digital platforms to obtain information and advice about lifestyle health. The results demonstrate that adolescents' methods for searching for lifestyle health information differ across online platforms, with active searching for information across platforms such as Google and YouTube and passive receiving of information across other social media including Facebook, Instagram, TikTok, and Twitter. Furthermore, adolescents desired information to be well-presented, credible, and relevant to them. The findings from this study can be used to inform future research into the development of effective online lifestyle health promotion strategies and interventions for adolescents.

Comparison With Prior Work

Previous research has shown that nearly 63% of adolescents use online information broadly to maintain a healthy lifestyle [22]. Many previous studies assessed online information as a whole, without differentiating between online platforms (eg, websites, social media). Our findings from this study appear consistent with previous research regarding the processes that adolescents use to search for health information online; however, this study elicited new findings across the different contemporary digital platforms. From an adolescent perspective, it is apparent why social media is favored over websites when it comes to lifestyle health information. Social media is a common feature in many adolescents' everyday lives, with mobile devices making access to social media more frequent and personalized [23]. Features available on social media platforms, such as Instagram stories and turning on notification features for favorite accounts, allow content to be highly engaging and of higher production quality. These features increased the perceived credibility of the account by adolescents and allow adolescents to curate who they follow on social media and thereby ensure that the information that they are digesting is relevant to them.

Processes used to search for lifestyle health information by adolescents included searching for information on websites and both actively and passively using social media platforms [17,22]. The passive nature of information exchange on social media is potentially increasing due to the increasing amount of targeted advertising across different social media platforms. In 2021, social media advertising was projected to reach Aus $199 million (US $21.7 million), which is a growth of 4.9% [24]. Users now have less control over the information content within their social media feeds [25]. A study by Hausmann et al [15] suggested only 25% of adolescents agreed that social media could help them obtain useful health information, despite almost ubiquitous use of social media among adolescents. In this study, participants identified several barriers to ascertain whether information on social media was useful. Such barriers included the use of sponsorships and advertising by companies and influencers on social media and the targeted nature of information due to algorithms employed on these platforms. eHealth literacy is the ability to seek, find, evaluate and appraise, integrate, and apply information to solve a health problem in an electronic environment [26]. eHealth literacy was not assessed as part of this study; however, adolescents demonstrated awareness of broad social media advertising and sponsorship strategies. Evaluations of eHealth literacy in the

context of contemporary digital platforms warrant further investigation.

Co-design is widely used in the development of eHealth interventions to increase their acceptability and effectiveness among adolescent populations, as they are particularly hard to engage [27,28]. This same methodology can be applied to the development of online health information to increase its appeal in terms of organization of information and relevance to adolescents. A previous systematic review of Australian websites found that very few websites were written specifically for adolescents and none were found to be excellent quality, interactive, and written in plain English [29]. This finding was also demonstrated in our study, with adolescents reporting that information found on websites was often too hard to understand, too difficult navigate, or not relevant to them. To ensure that information is presented in a format that adolescents understand and is relevant to them, co-design of online health information with adolescents could be utilized to increase its acceptability and effectiveness in management of chronic disease risk factors.

The digital space is highly unregulated, and this challenges the credibility of online health information. Due to the rise in user-generated content on digital platforms and popularity of using social media to access lifestyle health information, it is becoming increasingly difficult to regulate digital content, with authors often unidentifiable [30]. As explored in this study, participants reported a preference for "a face behind the account" and being clearly able to see their qualifications in the biography section of their profile to increase credibility and trust in the account. Furthermore, adolescents are acutely aware of advertising and sponsorships within content across social media platforms. The WHO has recognized the influence of food marketing as detrimental to children in many countries. Although regulations have been put in place surrounding advertising to children in Australia (aged 0-14 years) [31], regulations around the world rarely address adolescents [32]. This is despite an increase of more than US $400 million spend on advertising between 2012 and 2019 by the fast food industry targeting children and adolescents [33]. Social media platforms are commercial companies with advertising as their sole generation of income [34]. Currently, there are minimal laws surrounding advertising on social media in Australia, particularly sponsored posts [35]. For example, advertising of weight loss products in Australia must be truthful, accurate, and not mislead consumers [36], but this does not apply to sponsorships. It is important to note that adolescents currently have access to what they perceive as both helpful and harmful lifestyle health information online. Through the addition of regulation and legislation around these areas, there is the capability to make information more useful and credible and potentially lead to behavior change that is helpful for the prevention of chronic disease while also causing minimal harm. Therefore, the regulation of advertising toward adolescents is a challenging space, and further research is required to explore the influence of advertising on contemporary digital platforms toward lifestyle health behaviors of adolescents.

Strengths and Limitations

This qualitative study has several strengths as well as limitations. We were able to recruit a diverse sample of adolescents to take part in this study, including 41% of participants who spoke a language other than English at home and from different states throughout Australia. Also, this qualitative study is among the first to provide insights into perceived barriers and facilitators of lifestyle health information on contemporary digital platforms, allowing opinions and thoughts to be gathered from the target population. However, it should be emphasized that, as this study was advertised and took place virtually, it may limit the generalizability of the findings to adolescents with higher eHealth literacy skills. For this study, we did not capture data on the eHealth literacy skills of participants. It is possible that groups with lower eHealth literacy may also offer useful insights into their perceptions of online lifestyle health information.

Recommendations for Development of Online Lifestyle Health Information

Considering the findings from this qualitative study and previous research, a series of recommendations has been developed regarding the development of online lifestyle health information to ensure relevancy, appeal, and engagement for adolescents:

- Employ co-design of lifestyle health information with adolescents for contemporary digital platforms.
- Conduct further research into the regulation of online lifestyle health information for adolescents.
- Consider the eHealth literacy level of adolescents in the development of online lifestyle health information for contemporary digital platforms.

Conclusions

In summary, this study highlights the abundance and complexity of online lifestyle health information available to adolescents, which is exponentially growing across contemporary digital platforms. Adolescents in this study reported wanting access to information that was credible, appealing, and relevant to them. To develop effective online lifestyle health promotion strategies and interventions, future research should include co-design of information with adolescents and consider their eHealth literacy levels. Furthermore, the influence of advertising on contemporary digital platforms and regulations around this warrants further investigation.

Acknowledgments

The authors would like to acknowledge Ms Nicole Halim, Mr Matthew Armstrong, Ms Mariam Mandoh, Professor Philayrath Phongsavan, Ms Anna Singleton, and Dr Karice Hyun for their contribution to the cross-sectional study design and analysis, which informed this study.

RR is supported by a University of Sydney Postgraduate Research Scholarship in Digital Health, Youth and Nutrition. SSJ is supported by a University Postgraduate Award Scholarship. JR is supported by a National Health and Medical Research Council

Career Development Fellowship [APP1143538]. SRP is supported by a National Health and Medical Research Council and National Heart Foundation Early Career Fellowship [APP1157438].

Conflicts of Interest

None declared.

Multimedia Appendix 1

Consolidated criteria for reporting qualitative research (COREQ) checklist.
[DOCX File , 20 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Supplementary File 2: Focus Group Discussion Guide – Digitalize Study.
[DOCX File , 43 KB-Multimedia Appendix 2]

References

1. Adolescents overview. UNICEF. 2019 Oct. URL: https://data.unicef.org/topic/adolescents/overview/ [accessed 2022-02-04]
2. The adolescent brain: a second window of opportunity. UNICEF. 2017. URL: https://www.unicef-irc.org/publications/pdf/adolescent_brain_a_second_window_of_opportunity_a_compendium.pdf [accessed 2022-02-04]
3. Nagata JM, Ganson KT, Liu J, Gooding HC, Garber AK, Bibbins-Domingo K. Adolescent body mass index and health outcomes at 24-year follow-up: a prospective cohort study. J Am Coll Cardiol 2021 Jun 29;77(25):3229-3231 [FREE Full text] [doi: 10.1016/j.jacc.2021.04.071] [Medline: 34167649]
4. UNICEF. The State of the World's Children: Children, food and nutrition: growing well in a changing world. 2019. URL: https://www.unicef.org/reports/state-of-worlds-children-2019 [accessed 2022-02-04]
5. Guthold R, Stevens G, Riley L, Bull F. Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1·6 million participants. The Lancet Child & Adolescent Health 2020 Jan;4(1):23-35 [FREE Full text] [doi: 10.1016/s2352-4642(19)30323-2]
6. Obesity and overweight. World Health Organization. 2021 Jun 09. URL: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight [accessed 2022-02-04]
7. Australian Bureau of Statistics. Australian Health Survey: Nutrition and Physical Activity 2011-12. 2013. URL: https://www.abs.gov.au/statistics/health/health-conditions-and-risks/australian-health-survey-physical-activity/latest-release [accessed 2022-02-07]
8. National Health Survey: First Results. Australian Bureau of Statistics. 2017. URL: https://www.abs.gov.au/statistics/health/health-conditions-and-risks/national-health-survey-first-results/latest-release [accessed 2022-02-04]
9. Australian teens not getting enough sleep. Australian Government. 2019 Dec 3. URL: https://aifs.gov.au/media-releases/australian-teens-not-getting-enough-sleep [accessed 2022-02-04]
10. Sawyer SM, Azzopardi PS, Wickremarathne D, Patton GC. The age of adolescence. Lancet Child Adolesc Health 2018 Mar;2(3):223-228. [doi: 10.1016/S2352-4642(18)30022-1] [Medline: 30169257]
11. Akseer N, Mehta S, Wigle J, Chera R, Brickman ZJ, Al-Gashm S, et al. Non-communicable diseases among adolescents: current status, determinants, interventions and policies. BMC Public Health 2020 Dec 14;20(1):1908 [FREE Full text] [doi: 10.1186/s12889-020-09988-5] [Medline: 33317507]
12. Hargreaves D, Mates E, Menon P, Alderman H, Devakumar D, Fawzi W, et al. Strategies and interventions for healthy adolescent growth, nutrition, and development. The Lancet 2022 Jan;399(10320):198-210. [doi: 10.1016/s0140-6736(21)01593-2]
13. Lusk B. Digital natives and social media behavior: an overview. The Prevention Researcher 2010:173-176. [doi: 10.1037/e510232011-001]
14. Digital lives of Aussie teens. eSafety Commissioner. URL: https://www.esafety.gov.au/research/digital-lives-aussie-teens [accessed 2022-02-04]
15. Hausmann JS, Touloumtzis C, White MT, Colbert JA, Gooding HC. Adolescent and young adult use of social media for health and its implications. J Adolesc Health 2017 Jun;60(6):714-719 [FREE Full text] [doi: 10.1016/j.jadohealth.2016.12.025] [Medline: 28259620]
16. Wartella E, Rideout V, Montague H, Beaudoin-Ryan L, Lauricella A. Teens, health and technology: a national survey. MaC 2016 Jun 16;4(3):13-23. [doi: 10.17645/mac.v4i3.515]
17. Freeman JL, Caldwell PHY, Bennett PA, Scott KM. How adolescents search for and appraise online health information: a systematic review. J Pediatr 2018 Apr;195:244-255.e1. [doi: 10.1016/j.jpeds.2017.11.031] [Medline: 29398062]
18. Freeman JL, Caldwell PHY, Scott KM. The role of trust when adolescents search for and appraise online health information. J Pediatr 2020 Jun;221:215-223.e5. [doi: 10.1016/j.jpeds.2020.02.074] [Medline: 32446485]

19. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care 2007 Dec;19(6):349-357. [doi: 10.1093/intqhc/mzm042] [Medline: 17872937]
20. Armstrong M, Halim NK, Raeside R, Jia SS, Hyun K, Boroumand F, et al. How helpful and what is the quality of digital sources of healthy lifestyle information used by Australian adolescents? A mixed methods study. Int J Environ Res Public Health 2021 Dec 06;18(23):12844 [FREE Full text] [doi: 10.3390/ijerph182312844] [Medline: 34886569]
21. Gale NK, Heath G, Cameron E, Rashid S, Redwood S. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. BMC Med Res Methodol 2013 Sep 18;13:117 [FREE Full text] [doi: 10.1186/1471-2288-13-117] [Medline: 24047204]
22. Kang M, Robards F, Sanci L, Steinbeck K, Jan S, Hawke C, et al. project protocol: young people and health system navigation in the digital age: a multifaceted, mixed methods study. BMJ Open 2017 Aug 07;7(8):e017047 [FREE Full text] [doi: 10.1136/bmjopen-2017-017047] [Medline: 28790044]
23. Swist T, Collin P, McCormack J, Third A. Social media and the wellbeing of children and young people: A literature review. Commissioner for Children and Young People Western Australia. 2015 Jul. URL: https://www.westernsydney.edu.au/__data/assets/pdf_file/0019/930502/Social_media_and_children_and_young_people.pdf [accessed 2022-02-04]
24. Social Media Advertising. Statista. URL: https://www.statista.com/outlook/dmo/digital-advertising/social-media-advertising/worldwide?currency=AUD [accessed 2022-02-04]
25. Oremus W. Who Controls Your Facebook Feed. The Slate Group. 2016 Jan. URL: http://www.slate.com/articles/technology/cover_story/2016/01/how_facebook_s_news_feed_algorithm_works.html [accessed 2022-02-04]
26. Norman CD, Skinner HA. eHealth literacy: essential skills for consumer health in a networked world. J Med Internet Res 2006 Jun 16;8(2):e9 [FREE Full text] [doi: 10.2196/jmir.8.2.e9] [Medline: 16867972]
27. Colditz JB, Woods MS, Primack B. Adolescents Seeking Online Health Information: Topics, Approaches, and Challenges. In: Moreno MA, Radovic A, editors. Technology and Adolescent Mental Health. Cham, Switzerland: Springer; 2018:21-35.
28. Raeside R, Partridge SR, Singleton A, Redfern J. Cardiovascular disease prevention in adolescents: eHealth, co-creation, and advocacy. Med Sci (Basel) 2019 Feb 24;7(2):1 [FREE Full text] [doi: 10.3390/medsci7020034] [Medline: 30813490]
29. Ruan S, Raeside R, Singleton A, Redfern J, Partridge SR. Limited engaging and interactive online health information for adolescents: a systematic review of Australian websites. Health Commun 2021 May;36(6):764-773. [doi: 10.1080/10410236.2020.1712522] [Medline: 31964190]
30. Moorhead SA, Hazlett DE, Harrison L, Carroll JK, Irwin A, Hoving C. A new dimension of health care: systematic review of the uses, benefits, and limitations of social media for health communication. J Med Internet Res 2013 Apr 23;15(4):e85 [FREE Full text] [doi: 10.2196/jmir.1933] [Medline: 23615206]
31. Self-Regulation: Children's Advertising Code. The Australian Association of National Advertisers. URL: https://aana.com.au/self-regulation/codes-guidelines/aana-code-for-advertising-marketing-communications-to-children/ [accessed 2022-02-04]
32. World HO. Marketing of unhealthy foods and drinks. World Health Organization Regional Office for the Eastern Mediterranean. URL: http://www.emro.who.int/nutrition/marketing-of-unhealthy-foods/index.html [accessed 2022-02-04]
33. Harris JL, Fleming-Milici F, Phaneuf L, Jensen M, Choi YY, McCann M. Fast food advertising: Billions in spending, continued high exposure by youth. UConn Rudd Center for Food Policy & Obesity. 2021 Jun. URL: https://media.ruddcenter.uconn.edu/PDFs/FACTS2021.pdf [accessed 2022-02-04]
34. McFarlane G. How Facebook (Meta), Twitter, Social Media Make Money From You. Investopedia. 2021 Nov 04. URL: https://www.investopedia.com/stock-analysis/032114/how-facebook-twitter-social-media-make-money-you-twtr-lnkd-fb-goog.aspx [accessed 2022-02-04]
35. Social media. Australian Competition & Consumer Commission. URL: https://tinyurl.com/2p9cav2x [accessed 2022-02-04]
36. What restrictions are there for advertising weight loss products? Legal Vision. URL: https://legalvision.com.au/q-and-a/what-restrictions-are-there-for-advertising-weight-loss-products/ [accessed 2022-02-04]

Abbreviations

COREQ: consolidated criteria for reporting qualitative research
WHO: World Health Organization

Edited by S Badawy; submitted 23.11.21; peer-reviewed by J Freeman, M Vajravelu; comments to author 15.12.21; revised version received 17.12.21; accepted 03.01.22; published 11.02.22

Please cite as:
Raeside R, Jia SS, Redfern J, Partridge SR
Navigating the Online World of Lifestyle Health Information: Qualitative Study With Adolescents
JMIR Pediatr Parent 2022;5(1):e35165
URL: https://pediatrics.jmir.org/2022/1/e35165
doi: 10.2196/35165
PMID:

Appendix 1: Consolidated criteria for reporting qualitative research (COREQ) Checklist

Domain 1: Research team and reflexivity	
Personal Characteristics	
1. Interviewer/facilitator: Which author/s conducted the interview or focus group?	All 5 focus groups were conducted by RR, SJ was note taker, SRP supervised
2. Credentials: What were the researcher's credentials? E.g. PhD, MD	RR holds a MPH and BBiomedSc
3. Occupation: What was their occupation at the time of the study?	RR is a Research Officer
4. Gender: Was the researcher male or female?	RR is a female
Experience and training	
5. What experience or training did the researcher have?	RR has organised, supervised and taken notes for >8 focus groups and conducted >10 individual semi-structured interviews with research participants
Relationship with participants	
6. Relationship established: Was a relationship established prior to study commencement?	RR had no prior relationships with any of the adolescents who took part
7. Participant knowledge of the interviewer: What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	None of the participants knew the interviewer prior to the focus groups
8. Interviewer characteristics: What characteristics were reported about	No characteristics were reported

the interviewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	
Domain 2: study design	
Theoretical framework	
9. Methodological orientation and Theory: What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	Framework approach - thematic analysis
Participant selection	
10. Sampling: How were participants selected? e.g. purposive, convenience, consecutive, snowball	Convenience and snowball
11. Method of approach: How were participants approached? e.g. face-to-face, telephone, mail, email	Participants were invited via email and text message
12. Sample size: How many participants were in the study?	49 invited to take part 37 agreed to take part 32 included in final analysis
13. Non-participation How many people refused to participate or dropped out? Reasons?	2 declined 10 did not respond 5 agreed to take part but did not attend with no reason given
Setting	
14. Setting of data collection: Where was the data collected? e.g. home, clinic, workplace	Online using Zoom teleconference

15. Presence of non-participants: Was anyone else present besides the participants and researchers?	No
16. Description of sample What are the important characteristics of the sample? e.g. demographic data, date Data collection	Demographic data
17. Interview guide: Were questions, prompts, guides provided by the authors? Was it pilot tested?	Questions were asked by the interviewer but not provided to participants. Discussion guide was pilot tested with 2 youth advisors
18. Repeat interviews: Were repeat interviews carried out? If yes, how many?	5x focus groups were held until thematic saturation was reached
19. Audio/visual recording: Did the research use audio or visual recording to collect the data?	Audio recording was used to collect data via Zoom teleconference and iPhone voice memos
20. Field notes: Were field notes made during and/or after the interview or focus group?	Yes, during
21. Duration: What was the duration of the interviews or focus group?	45 minutes
22. Data saturation: Was data saturation discussed?	Yes
23. Transcripts returned: Were transcripts returned to participants for comment and/or correction?	No
Domain 3: analysis and findings	
Data analysis	

24. Number of data coders: How many data coders coded the data?	Two data coders with discrepancies checked by third independent coder
25. Description of the coding tree: Did authors provide a description of the coding tree?	Yes
26. Derivation of themes: Were themes identified in advance or derived from the data?	Derived from the data
27. Software: What software, if applicable, was used to manage the data?	Transcripts produced in Microsoft Word (Version 16.54), thematic analysis in NVivo 12 (12.2.0)
28. Participant checking: Did participants provide feedback on the findings?	No
Reporting	
29. Quotations presented: Were participant quotations presented to illustrate the themes / findings? Was each quotation identified? e.g. participant number	Yes
30. Data and findings consistent: Was there consistency between the data presented and the findings?	Yes
31. Clarity of major themes: Were major themes clearly presented in the findings?	Yes
32. Clarity of minor themes: Is there a description of diverse cases or discussion of minor themes?	Yes

Appendix 2: Focus Group Discussion Guide – Digitalize Study

Introductions

Moderator to briefly introduce themselves and mention anyone assisting and/or observing the session.

Inform the need to audio record the session and remind participants the session will not be video recorded so they can keep their cameras on if they would like to and feel comfortable to do so.

Explain that participants can withdraw from the focus group at any time; however, any contribution to the discussion prior to withdrawal cannot be removed from the recording or written transcript.

Introductions

Have young people introduce themselves

Explain the purpose of the project and bring up respectful discussion

Main purpose

Explain purpose of project

- We are a research group at The University of Sydney conducting a research project to look at how and which digital platforms young people are using to seek lifestyle health-related information online. We also want to understand how helpful these platforms are for health advice
- The group discussion that we will be having will last approximately 60 minutes and we will take short breaks to stretch and check everyone is doing ok.

Respectful discussion

Explain the importance of everyone contributing respectfully to the discussion, particularly if they feel differently to the person next to them:

- We will put a link to the participant information sheet in the group chat, please save a copy if you haven't done so already. There is a list of contacts you can talk to and websites you can access if you feel distressed or upset, if that is what you want to do
- When you feel like you have something to say, please do so. There are many of you in the group and it is important that you all get a chance to express your views.
- Please stay on mute when you are not talking so we can hear everyone clearly.

- There are no right or wrong answers; you do not have to agree with the views of other people in the group.
- You do not have to speak in any particular order.
- While I want to hear what each one of you has to say, it is important that only one person speaks at a time.
- Please keep what is said in this group confidential, by that we mean don't repeat what is said in the focus group to anyone else
- Please keep your mobile phones on 'silent mode'
- Does anyone have any questions before we start our group discussion?
- We will check in with everyone at various points during the online interaction to see how everyone is going

For this discussion, 'lifestyle health and wellbeing' refers to physical activity, nutrition/diet, weight management and sleep. When we refer to 'online sources' we are interested in social media platforms, smartphone apps, internet websites and on-demand video/streaming services.

Overall

1. Where do you access health information online?
    a. Prompt: social media platforms, smartphone apps, internet websites and on-demand video/streaming services
2. Why do you seek health information online?
    a. Prompt: Convenience? Do you talk to your GP or other health professionals about this health information? Friends/family? Why/Why not?
3. What type of health content do you find most engaging?
    a. Prompt: diet, physical activity, weight management, sleep etc?
4. How helpful do you feel the health content is that you have accessed online?
    a. Prompt: why/why not?
5. Can you think of a time that you changed something you did (in terms of your health) because of something you saw online?

a. Prompt: No change or was this a positive or negative change?

6. What would improve your experience of seeking health information online?
    a. Prompt: What content would you like to see more/less? Which platforms? A person behind the account?

***** CHECK IN – MAKE SURE EVERYONE IS OK AND OFFER BREAK OUT ROOMS IF NEEDED*****

Moderator to proceed with questions related to the 2 platforms most of interest to the group:

You mentioned <*insert most popular platform e.g., social media*> and <*insert most popular platform e.g., social media*>, let's chat more about those 2 platforms.

Social media → proceed if top 2 from Q1

7. What social media platforms do you use to look for health information?
    a. Prompt: Instagram, TikTok, Facebook, snapchat
8. What are the reasons behind deciding to follow a particular social media account for health information?
    a. Prompt: regular engagement, new content, size of their existing following, the person?
9. What makes a social media account most appealing to follow for health information?
    a. Prompt: what are the key features i.e., high quality of photos/videos, length of videos, multiple photos, stories, body focused accounts, content topics
10. What makes a social media account least appealing to follow for health information?
    a. Prompt: what are the key features i.e., low quality of photos/videos, no face or person behind the account
11. Do you assess the reliability and usefulness of the account?
    a. Prompt: Credentials, blue tick, celebrity

Websites → proceed if top 2 from Q1

12. How do you search for websites regarding information on lifestyle health information?

a. Prompt: What search terms do you use? Do you visit same websites regularly?

13. What make health information website most appealing to use?

    b. Prompt: website lay out, information, interactivity, do you find the language of websites hard to understand?

14. What make health information website least appealing to use?

    c. Prompt: website lay out, information, interactivity

15. How did you assess the reliability and usefulness of the health information you have looked up online?

    d. Prompt: How do you decide if a website is trustworthy? Known organization or individual?

***** CHECK IN – MAKE SURE EVERYONE IS OK AND OFFER BREAK OUT ROOMS IF NEEDED*****

Apps → proceed if top 2 from Q1

16. How do you find health information apps to download?

    a. Prompt: word of mouth, app store

17. What make health information apps most appealing to use?

    a. Prompt: subscription fees, features, data ownership

18. What make health information apps least appealing to use?

    a. Prompt: subscription fees, features, data ownership

19. Do you assess the reliability and usefulness of the app?

    a. Prompt: Credentials, number of followers, recommendations from friends etc.?

Streaming services → proceed if top 2 from Q1

20. When you watch lifestyle-related content on streaming services such as Netflix, Stan etc., how do you decide if the information presented to you is trustworthy or not?

a. Prompt: do you do any further searching on the health topic?

21. What makes lifestyle-related content on streaming services most appealing to watch?
    a. Prompt: quality, presenters
22. What makes lifestyle-related content on streaming services least appealing to watch?
    a. Prompt: quality, presenters

Conclusions → All

***** CHECK IN – MAKE SURE EVERYONE IS OK AND OFFER BREAK OUT ROOMS IF NEEDED*****

23. Are there any final comments you would like to make about the content we have discussed today?

Many thanks for your time and contribution

Chapter One

Introduction

Chapter Two

Systematic Review with Meta-Analysis

Chapter Three

Qualitative Study with Adolescents

HEALTH4ME

Chapter Four

Co-Design of Health4Me

Chapter Five

Health4Me RCT Protocol

Chapter Six

Health4Me Recruitment

Chapter Seven

Qualitative Study with Stakeholders

Chapter Eight

Discussion and Conclusions

CHAPTER FOUR: Striking the right balance: co-designing the Health4Me healthy lifestyle digital health intervention with adolescents

Preface to the Chapter

Chapter Three provided evidence that there is an abundance of lifestyle health information online and it is complex. Adolescents desire information that is appealing, credible, relevant and actionable to support improvement of health behaviours. This chapter (Chapter Four) presents the findings of co-design process for the Health4Me text message intervention titled 'Striking the right balance: co-designing the Health4Me healthy lifestyle digital health intervention with adolescents', thereby addressing Aim 4 of this thesis. Ethics approvals and participant information and consent forms for this study are presented in Appendix C. The youth perspective article which frames the content areas for this study, and commentaries from both researchers and young people on operating a youth advisory group are available in Appendix F. This paper has undergone peer review (submitted 30th August 2023, accepted 28th November 2023) and published (7th December 2023) in *Research Involvement and Engagement.* Authors contributions to this paper are outlined in the authorship attribution statement. Chapter Four was disseminated in the following ways:

Published peer reviewed manuscript

Raeside R, Todd A, Wardak S, Gardner L, Champion KE, Kang M, Mihrshahi S, Steinbeck K, Redfern J, Partridge SR, HAPYUS, The Health4Me Team. Striking the right balance: co-designing the Health4Me healthy lifestyle digital health intervention with adolescents. Research Involvement and Engagement 2023; 9:114. https://doi.org/10.1186/s40900-023-00524-4

Conference presentations

1. **Raeside R** et al (11-14/08/2022) Co-designing the Health4Me text message intervention to support and improve adolescent's physical and mental health outcomes: an active research partnership with adolescents. 5-min oral. Cardiac Society of Australia and New Zealand Annual Meeting 2022, Gold Coast, Queensland, Australia
2. **Raeside R** et al (18-21/05/2022) Co-design of health4me: a healthy lifestyle text message program for adolescents. 10-min oral (symposium). International Society of Behavioural Nutrition and Physical Activity Annual Meeting 2022, Phoenix, Arizona, USA

Author attribution statement

This statement is to stipulate the contribution of Rebecca Raeside in the preparation and submission of the following manuscript: ‘Striking the right balance: co-designing the Health4Me healthy lifestyle digital health intervention with adolescents‘. The convention is that the author with the principal contribution to the study is the first author.

Rebecca Raeside, during her PhD candidature, developed the concept for the study, was responsible for designing and refining the research question, recruited participants, designed and refined the content, analysed the data, drafted the manuscript and subsequent revisions and coordinated submission for publication.

The individual roles of co-authors are listed below:

TASK	ROLE OF CO-AUTHORS
STUDY CONCEPTION AND DESIGN	RR, JR, SRP
RECRUITMENT, DATA COLLECTION, ANALYSIS	RR, AT, SW, SRP
TEXT MESSAGE CONTENT DESIGN	ALL
TEXT MESSAGE REFINEMENT	RR, AT, SW, LG, KEC, SM, SRP, HAPYUS
DRAFTING MANUSCRIPT	RR, AT, SRP
REVISION AND CRITICAL COMMENTS ON MANUSCRIPT	ALL
MANUSCRIPT SUBMISSION	RR

Rebecca Raeside 26 Sept 2024

As supervisor for the candidature upon which this thesis is based, I can confirm that the author attribution statement above is correct.

Dr Stephanie Partridge 26 Sept 2024

Raeside et al.
Research Involvement and Engagement (2023) 9:114
https://doi.org/10.1186/s40900-023-00524-4

Research Involvement and Engagement

RESEARCH Open Access

Striking the right balance: co-designing the Health4Me healthy lifestyle digital health intervention with adolescents

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Abstract

Background Adolescents are navigating a period of rapid growth and development within an era of digitalization. Mobile phone ownership among adolescents is nearly ubiquitous, and this provides an opportunity to harness text messaging to promote a healthy lifestyle and reduce chronic disease risk factors. Inclusion of adolescents throughout the design process has been recognized as essential for engagement and future implementation of such interventions. This study aimed to co-design a bank of text messages to promote a healthy lifestyle which are useful, acceptable, and engaging for adolescents aged 12–18 years old.

Methods Iterative, mixed-methods design with consumer partnership. Co-design occurred over three stages: text message development, text message review and final refinement and testing. The text message development included literature searches and consumer partnership with an established youth advisory group (n = 16). Participants who gave e-consent participated in text message review. Demographic characteristics were collected, and quantitative surveys were distributed to adolescents (n = up to 50) and health professionals (n = up to 30), who rated text message content for understanding, usefulness and appropriateness (total score out of 15). Final refinement was completed by the research team to edit or remove messages which had low scores and to assess readability and interactivity of the text messages.

Results The Heath Advisory Panel for Youth at the University of Sydney (HAPYUS) identified the top six lifestyle health issues for young people today in relation to chronic disease prevention, which became the key content areas for the text message bank and drafted new text messages. Following text message development, 218 messages were available for review. Adolescents (n = 18, mean age 16.3 [SD 1.4]) and healthcare professionals (n = 16) reviewed the text messages. On average, all reviewers found that the text messages were easy to understand (mean = 13.4/15) and useful (mean = 12.7/15). Based on scoring and open ended-feedback, 91 text messages were edited and 42 deleted. The final text message bank included 131 text messages. The overall program is suitable for a seventh-grade reading level, and interactive.

Conclusions This study describes the process of effectively engaging adolescents to co-design a text message bank intervention, which are useful, acceptable and engaging for an adolescent audience. The effectiveness of the co-designed text message bank is currently being tested in the Health4Me RCT.

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Keywords Adolescent, Co-design, Text-message, Behavior change, Intervention, Prevention, Digital health

Plain English Summary

Today's adolescents are growing and developing through a period of increased technology use. Most adolescents have access to a mobile phone which can be used to deliver healthy lifestyle information to them through text messages. However, it is important that researchers engage with adolescents as collaborators to develop any information which may be sent to them, to ensure that it is acceptable and engaging. We aimed to co-design a bank of text messages to promote a healthy lifestyle which are useful, acceptable and engaging for adolescents 12–18 years old. We engaged with 16 adolescents from an established youth advisory group who advised on top health issues they face today in terms of leading a healthy lifestyle, which became key content areas for the text message program. They also drafted text messages around these content areas (218 total). Next, the text messages underwent review with 34 adolescents and healthcare professionals to ensure they were useful, easy to understand and appropriate. After the review, the research team edited, deleted and replaced text messages which did not score well. This resulted in a text message bank to promote a healthy lifestyle with 131 text messages which were useful, acceptable and engaging for adolescents 12–18 years old.

Introduction

Adolescence is a period of significant biological and neurocognitive growth, emotional development, and social change. Some of the biggest challenges facing adolescents in Australia today are unhealthy diets, physical inactivity, excessive screen time, sedentary behavior and poor sleep, all of which have been linked to poor physical and mental health, including overweight/obesity, anxiety, depression and psychological distress [1]. Today's adolescents are navigating this crucial period of life amid the rapid wave of digitalization [2]. Their engagement with digital media, such as smartphones, the internet, and social media, exposes them to a diverse spectrum of advantages and challenges that can impact their physical and mental health [3]. Emerging research demonstrates that there is potential for digital health lifestyle interventions to improve the physical and mental health of adolescents [4, 5]. It is vital that health services provide solutions which meet the needs of adolescents through engaging digital media and equipping them with information and tools to combat the challenges they face. This will assist in the development of healthy lifestyle behaviors which they can carry throughout life and reduce future risk of non-communicable diseases, including cardiovascular disease, type 2 diabetes and mental ill-health.

Adolescent mobile phone ownership has grown internationally, and 9 in 10 Australian teenagers have a mobile phone [6]. With that comes the opportunity to harness these devices to provide information and tools to adolescents to improve their lifestyle health behaviors through mobile applications, social media and text messaging. Though social media is popular amongst adolescents, a previous meta-analyses of social media interventions for diet and exercise behaviours showed no significant differences between groups and had low levels of participation [7]. Furthermore, there are challenges to running these interventions including the need to separate control for the effects of existing social media structures [8] and how to effectively evaluate the intervention [9]. Text message strategies are the most accessible, as these are low-cost to send, free to receive and do not require an internet connection [10]. It is important to ensure that digital health tools are not driving digital exclusion and health inequalities due to limited access or ability of recipients to use them, or cost [11]. Additionally, text messaging is the preferred form of communication for adolescents [12]. Its use may overcome barriers to preventive health care, including cost of visits, transport to and from services and opening hours [13]. Previous research has shown that texting can help adolescents navigate key developmental challenges including establishing autonomy, facilitating connection with peers and self-identity [14]. However, there is limited research on text message programs aimed at promoting health and preventing chronic disease among otherwise healthy adolescents through the improvement of lifestyle health behaviors.

It is a human right that adolescents are engaged in research and policy development which impacts their own health [15]. Furthermore, the World Health Organization recommends that young people should be included in every stage of the research process when developing digital health interventions, and that their engagement should be sustained and meaningful [16]. Traditional adolescent engagement in research has been tokenistic. A recent scoping review showed that just 11% of all research on obesity prevention engaged adolescents in all five stages of the research cycle (identification of topic, design or development, conduct, analyses and dissemination) and only 9% of studies involved an adolescent-led approach [17]. Adolescents need to be leaders in

decisions about their health for impacts to be seen now and for generations to come. Yet for this to occur, a shift in power is necessary.

Co-design of digital health interventions with adolescents is a potential solution, a process in which active collaboration occurs between stakeholders (adolescents, healthcare professionals, researchers) in designing solutions to a pre-specified problem [18]. Considering digital health interventions are increasing in popularity for health-related behavior support, it is essential that they are co-designed with adolescents. Though many frameworks for co-design are available, no existing frameworks are specific to adolescents, and it has been suggested that locally relevant co-design activities may be more useful than a one-size-fits-all framework [19]. There must be an equal relationship, where consumers can co-lead the development, design and implementation process to tailor interventions to their lived experience around their values, goals and development. A previous systematic review found four overarching themes which affect engagement and enrolment in digital health interventions including: personal agency and motivation, personal life and values, the approach used for engagement and recruitment and the quality of the intervention itself [20]. Therefore, digital health interventions which do not take co-design into account can lead to disengagement and enrolment issues that adversely impact the implementation phase [21].

The Health4Me Study is a randomized controlled trial aiming to determine the effectiveness of a co-designed 6-month text message program to improve adolescents' healthy lifestyle behaviours. In brief, the intervention group receive a 6-month text message program (4–5 text messages per week) with optional monthly health counselling. The trial is currently in the recruitment phase and the full study protocol has been previously published [22]. The aim of this study is to co-design a bank of text messages that promote a healthy lifestyle which are useful, acceptable, and engaging for adolescents aged 12–18 years. The co-designed message bank will be tested for effectiveness in the Health4Me study.

Methods

Study design

This study employed an iterative, mixed-methods study design, with consumer partnership to co-design the Health4Me text message bank. This process involved adolescents aged 12–18 years and a variety of healthcare professionals and researchers (across fields of public health, behaviour change, physical activity, nutrition and psychology). The co-design occurred over three stages: (i) text message content development, including literature search and consumer partnership (ii) text message review following a previously published process [23, 24] and (iii) final refinement and programming. This study was conducted between July 2022–January 2023. Ethics approval was obtained from the University of Sydney Human Research Ethics Committee (approval number: 2022/402).

Text message development

The aim of this stage was to develop the initial bank of text messages. Several strategies were employed to develop the text message program including (i) an initial search of published literature to identify key behavior change techniques to underpin the text messages which may be effective among adolescents and (ii) online collaboration via monthly meetings over 12 months and a 1.5-h workshop with an established youth advisory group (The Health Advisory Panel for Youth at the University of Sydney; HAPYUS). HAPYUS is comprised of 16 members (aged 13–18 years) from across the state of New South Wales, Australia and serve a 12-month term as collaborators with the research team. The youth advisory group is informed by Youth Participatory Action Research principles [25], (i) inquiry based, topics of discussion were grounded in youth advisors lived experience and concerns related to chronic disease prevention; (ii) participatory, youth advisors are collaborators in the research process; and (iii) transformative, youth advisors will actively intervene to change research to improve the lives of youth and their communities from the negative impacts of chronic diseases.. Within the structure of the youth advisory group, adolescents were provided with opportunities to co-lead and contribute to chronic disease prevention research projects. The lead author presented to HAPYUS about the Health4Me Study to give them background and context to what they were being asked to contribute to, as some elements were predetermined. What was predetermined is that the intervention would be delivered via text messages and that it would run for 6-months. Within the capability of the text message delivery software, text messages can be scheduled to be sent at different times and on different days. HAPYUS were first asked to identify the top lifestyle health issues for young people, which became the key content areas for the intervention. At the in-person meeting they were then asked to draft text messages for adolescents 12–18 years old who have no chronic medical conditions, determine the frequency of messages to be sent per week and comment on the time of day that they would like to receive text messages. A young person research assistant (SW) worked with HAPYUS to collate the drafted text messages.

Text message review

The aim of this stage was to test the content of the draft text message bank using a mixed-methods survey based on a previous published process [23, 24]. The text messages developed in the first stage were combined with an existing bank of 107 co-designed text messages [24, 26]. Each text message was rated six times, three times by adolescents from the public and three times by health professionals or researchers. Each participant rated 40 text messages, and adolescents were compensated for their time with a $30AUD gift voucher.

Participants

Adolescents were included if they (i) were aged 12–18 years; (ii) provided informed e-consent (or with their parents or guardians consent if ≤ 14 years old). Adolescents were excluded if they (i) had a medical condition that precluded informed consent or their ability to comply with the study protocol; (ii) were unable to read English at a 7th grade level. Adolescents who were part of the youth advisory group were unable to take part in this process. Professionals were included if they (i) were multidisciplinary clinical and research experts including, but not limited to dietitians, physiotherapists, psychologists, exercise physiologists, general practitioners, behavioral science experts and public health researchers; (ii) provided informed e-consent. Recruitment of adolescents occurred through convenience sampling via mailing lists of young people who consented to being contacted for research participation by the research team, and professionals were recruited through known networks to the research team. Adolescents and professionals were invited via email, directed to read the participant information sheet and provide informed e-consent if they wished to take part.

Data collection and feedback

First, demographic characteristics were collected for adolescents and healthcare professionals who had experience working with adolescents. Demographics collected from adolescents included age, gender, language spoken most at home, education and postcode. Postcode was used to determine participants' Index of Relative Socio-economic Advantage and Disadvantage (IRSAD), which codes postcodes into quintiles from 1 (most-disadvantaged area) to 5 (least disadvantaged area) [27]. Demographics from professionals included age, gender and area of expertise. Text messages were placed into surveys comprised of 20 text messages, with some surveys about one topic and some about mixed topics. This helped to ensure that professionals were reviewing text messages most relevant to their area of expertise. For each message, the survey comprised two questions around understanding (able to comprehend what the message is saying) and usefulness (able to be practically used or used in several ways) on a 5-point Likert scale (response options: 1. Strongly disagree, 2. Disagree, 3. Neutral, 4. Agree, 5. Strongly agree), one question around age appropriateness (response options: 12–14 years of age, 15–16 years of age, 17–18 years of age) and a final open-ended question where suggestions for improvement could be made.

Analysis

Scores (15 indicating the best score) for understanding and usefulness were calculated separately for adolescents and professionals by summing the scores of each reviewer (5 points each, 5 indicating the best score). Any text messages which scored fewer than 12 points across any category were edited or excluded. All open-ended feedback was summarized, and concerns or suggestions were adhered to. An updated text message bank was then available for final checks and text message delivery system testing.

Final refinement and testing

The aim of this stage was to consolidate the findings of the development and review stages to ensure the final text message bank was ready for effectiveness testing in a six-month healthy lifestyle intervention trial. Firstly, text messages were added back into their respective categories to ensure that there were adequate text messages in each. Secondly, the readability of each text message was calculated using the Flesch-Kincaid readability score [28]. This score represents an approximate education level an individual would need to have to understand the reading material considering the number of syllables per word and number of words per sentence. Finally, the number of hyperlinks and two-way messages within the program was calculated to understand the interactivity of the program. All text messages were reviewed one final time by the young person research assistant and programmed for a test delivery into the text message software.

Results

Text message content development

Multiple studies were identified in the literature search which supported the use of different behavior change techniques and theories. Rose and colleagues conducted a systematic review of digital interventions for improving the diet and physical activity behaviors of adolescents and found that significant behavior change was seen when education, goal setting, self-monitoring and parental involvement were included [4]. Martin and colleagues conducted a systematic review of effective behavior change techniques for prevention or management of childhood obesity and found that only 'prompting

generalization of a target behavior' was effective for causing behavior change for obesity prevention [29]. For this study, we used the CALO-RE Taxonomy of behaviour change techniques [30], which is based on Abraham and Michie's initial taxonomy [31], with a specific focus on physical activity and healthy eating. The following behaviour change techniques derived from the literature search were applied to the initial text messages: goal setting, action planning, prompt generalization of a target behavior, provide instruction on how to perform the behavior, plan social support and prompt self-talk.

Through online collaboration, HAPYUS created a mind-map to identify the top lifestyle health issues for young people today in relation to chronic disease prevention. They identified six key issues: unbalanced nutritional intake, physical inactivity, mental health concerns, body image, rise of social media and climate change [32]. These became the six key content areas for the Health4Me text message program. In July 2022, an in-person workshop was held with 9/16 HAPYUS members able to attend. During the 1.5-h workshop, 105 new text messages were developed in alignment with the six key content areas. In addition, linking adolescents to primary care services was an overall theme which the research team deemed as important for preventive health care and therefore six messages were added (one per month). Therefore, a total of 111 new text messages were available. Post-workshop, the research team edited these text messages briefly to ensure that they were evidence-based and included behaviour change techniques. During the workshop, a consensus was reached on the timing and frequency of text messages. The adolescents revealed that receiving messages before and after school would be acceptable, but to consider the content and deliver at the appropriate time (e.g., deliver text messages about sleep in the evening). Furthermore, it was decided that messages should be less frequent at the start of the program and increase as the program continues. Taken together, a program where adolescents receive four text messages per week at the start and increases to five per week, is optimal. Patient and public involvement in the study is outlined in Additional File 1.

Text message review

A total of 218 text messages were available for review, combining the 111 new text messages developed and 107 existing co-designed text messages. The bank of 218 text messages were reviewed by 34 participants (Table 1). Adolescents (n = 18) had a mean age of 16.3 years (SD 1.4), with 8 male, 8 female and 2 non-binary/gender diverse participants, who mostly spoke English at home (17/18) and were predominantly from IRSAD quintiles four and five, corresponding to least disadvantaged areas (10/17). Sixteen professionals participated who were predominantly 30–39 years of age (9/16), and female (12/16).

On average, expert reviewers found that the text messages were easy to understand (13.7/15) and useful (13.3/15), as did adolescent reviewers (13.2/15 for understanding and 12.1/15 for useful). A total of 96 of the 218 text messages scored less than 12 by at least one participant. Based on scoring and open-ended feedback, 91 text messages were edited and 42 were deleted, leaving 176 messages from the review process. Text messages which scored highly gave practical examples, contained links, and focused on elements other than just physical health. Common edits to text messages were wording changes to make age-appropriate, sentence restructure, and concept definition. Table 2 displays examples of text messages which were included, edited, replaced, and deleted.

Following scoring and editing, text messages were placed into their respective topic categories to determine how many were required. Similar text messages were combined and those with lower scores were removed to create the final text message bank. When assessing the age-appropriateness of text messages, 28 were deemed inappropriate for 12–14-year-old participants, nine were inappropriate for 15–16-year-old participants and eight were inappropriate for 17–18-year-old participants. Considering the split and difference in age-appropriate text messages, two streams of text messages were created, one stream for adolescents aged 12–14 years and one for adolescents aged 15–18 years. Text messages deemed inappropriate were deleted or replaced with an age-appropriate message in their respective programs. An overview of text message numbers for each category is available in Table 3.

Final refinement and testing

The final text message bank comprised 131 messages (Fig. 1); frequency of message topics was nutrition n = 32, physical activity n = 26, mental health n = 27, body image n = 12, media n = 10, climate n = 10 and primary care n = 6. In addition, there was an introductory and final text message (n = 2), and six messages encouraging communication with the health counsellor.

Almost half of the text messages simultaneously addressed two behaviour change techniques. Text messages addressed goal setting (n = 56), action planning (n = 25), prompt generalization of a target behavior (n = 17), provide instruction on how to perform the behavior (n = 43), plan social support (n = 14) and prompt self-talk (n = 9). The average Flesch Kinkaid readability score for the Health4Me program was 75.4 (SD 12.9), indicating that the overall program is fairly easy to read and suitable for a seventh-grade (12–13 years old) reading level. Most text messages (n = 85) were rated very easy

Table 1 Participant characteristics (n = 34)

Adolescents	**N = 18**
Age (mean years ± SD)	16.3 ± 1.4
Gender	
Female	8
Male	8
Non-binary/gender diverse	2
Language spoken at home[a]	
English	17
Current high school student	
Years 7–8	1
Years 9–10	4
Years 11–12	12
Not attending school	1
IRSAD quintile	
1 (least disadvantaged)	7
2	3
3	5
4	1
5 (most disadvantaged)	2
Professionals	**N = 16**
Age	
18–29	3
30–39	9
40–49	2
50–59	2
Gender	
Female	12
Male	4
Area of Expertise[b]	
Physical activity	2
Nutrition and diet	6
Medicine	3
Public Health	8
Prevention	8
Behaviour change	6
Psychology	3
Other	1

SD Standard deviation, *IRSAD* Index of Relative Socio-economic Advantage and Disadvantage

[a] Other language spoken at home was Hindu

[b] Professionals could pick more than one area of expertise

to read to fairly easy to read (5th–7th grade reading level; 11–13 years of age), 30 messages were in plain English (8 to 9th grade reading level; 13–15 years of age), 16 messages scored fairly difficult to read (10–12th grade reading level; 16–18 years of age). Small punctuation edits were made to these messages, where possible, to reduce the scores. There were six messages which encouraged interaction with the health counsellor with one sent each month of the program. Twenty-nine text messages encouraged two-way communication, and 47 text messages contained links to external websites (e.g., recipe or exercise ideas, further information, referring to available services). Only three text messages differed between the 12–14 and 15–18-year-old text message streams. A final delivery system check was completed with 55 text messages sent over 14 days to 5 members of the research team, with all successfully delivered, and with 15 replies from the research team noted in the system.

The Health4Me intervention

Based on results of the co-design process, some specific elements were decided upon for the Health4Me intervention. For the first 13 weeks of the intervention participants receive four text messages per week, which increases to five text messages per week in the last 13 weeks. Each week participants in the intervention group will receive one text message on nutrition, one text message on physical activity, and a mix of two to three text messages from other topics. Once enrolled in the correct text message stream for their age, all participants will receive the same text messages. Text messages will be personalized with the participants preferred name. Engagement with the text message program will be assessed through text message data and a study-specific user feedback and satisfaction questionnaire.

Discussion

This study describes a novel way to co-design a healthy lifestyle text message intervention which is useful, engaging and acceptable for adolescents. A unique aspect of this study is putting adolescents at the forefront to advise on content areas which they consider are most influential on their lifestyle health behaviors in a modern context. Through an iterative co-design process, a bank of 131 evidence-based text messages which are easy to understand and acceptable to adolescents were developed. This study engaged a youth advisory group (HAPYUS), adolescents from across Australia, and health professionals to incorporate contemporary issues as the key content areas of the text message bank. The intervention is grounded in behaviour change techniques and through the text message review, messages which scored highly gave practical examples, contained links and focused on elements other than just physical health.

Traditionally, preventive health for adolescents focuses on high-risk behaviors including sexual activity, alcohol and substance use and smoking, in addition to physical activity and nutrition behaviors [33]. However, adolescents from the youth advisory group identified contemporary influences which are vital to consider in a preventive health context. including the rise of social

Table 2 Example text messages and scoring for text message inclusion, exclusion, replacement and editing

	Original message	Scores	Comments	Edited message
Edited	Hey you, yes you! Reminding you to take a break from the screens—your eyes need a rest. How about 15 min outside to get some fresh air too!	P[a]: 15/15 for understanding, 15/15 for usefulness A[b]: 14/15 for understanding, 13/15 for usefulness	A1: The start bit is a little cringey A2: Good message	Hi [pref_name], reminding you to take a break from the screens—your eyes need a rest. How about 15 min outside to get some fresh air too!
Edited	We understand its really tough to manage your time when all of your assessments are due at the same time! It can be rough. Hang in there [pref_name]. You're doing great!	P: 12/15 for understanding, < 12/15 for usefulness A: 15/15 for understanding, 14/15 for usefulness	P: A link to time-management or study skills resources could be helpful A: Maybe provide some solution to this issue? I know this is a source of stress for a lot of students, myself included	We understand its really tough to manage your time when all of your assessments are due at the same time! It can be rough. Hang in there [pref_name]. You're doing great! Learn some tips here: https://au.reachout.com/articles/how-to-manage-your-time
Included	We can help the environment and improve our health at the same time! A win–win, text back if you have done any of the following this week: (a) used a reusable water bottle; (b) ate less processed foods; (c) used reusable food containers, or (d) all of the above!	P: 14/15 for understanding, 15/15 for usefulness A: 14/15 for understanding, 14/15 for usefulness	P: Great, loved this message! Can help the participant feel good about themselves if they have managed to do some of the options listed: A: can provide opportunity for interaction for those who havent done the options	No change
Included	Complimenting your friends or family members on an aspect of their personality or behaviour, rather than on their appearance can brighten their mood—it can also make you happier knowing you made someone smile!	P: 15/15 for understanding, 15/15 for usefulness A: 14/15 for understanding, 15/15 for usefulness	P: love it	No change
Excluded	What if soy milk is just regular milk introducing itself in Spanish? Hola! Soooy funny. Soy milk isn't Spanish. It's made from soybeans, which are naturally low in calcium. If you drink soy milk, make sure to grab one with extra calcium added in so you can build strong bones!	P: < 12/15 for understanding, 14/15 for usefulness A: < 12/15 for understanding, < 12/15 for usefulness	P: I love this	Deleted
Excluded	I hear bouldering's really popular nowadays—why not try it at a rock climbing centre and see if you like it, [pref_name]?	P: 14/15 for understanding, 13/15 for usefulness A: A: < 12/15 for understanding, < 12/15 for usefulness	A: Why bouldering? Is there an actual purpose to why you said that? Why not something more approachable for a beginner—because bouldering is not	Deleted
Replaced	Leafy greens like spinach are packed with protein, so they're great for building muscles. How about in a blue smoothie? Just blend 1 cup frozen blueberries + 1 cup milk + 1 tsp honey + 2 cups of baby spinach (you won't taste it!)—[centre_name]	3/6 voted not appropriate for 12–14-year-olds	N/A	Replaced in 12–14 years old message stream with message below
Replaced	Did you know elephants and gorillas are some of the strongest animals on the planet and are also herbivores? Remember to keep greens in your diet to stay strong!	2/6 voted not appropriate for 17–18-year-olds 1/6 voted not appropriate for 15–16-year-olds	N/A	Replaced in 15–18 years old message stream with message above

[a] Professional reviewer

[b] Adolescent reviewer

Table 3 Overview of number of text messages through the text message review process

Topic of text message content	Total number of text messages[a]	Number of text messages post-review	Number of text messages in Health4Me program
Nutrition	56	47	32
Physical Activity	41	30	26
Mental Health	50	41	27
Body Image	21	18	12
Media	14	11	10
Climate	30	23	10
Primary Care	6	6	6
Total:	218	176	123[b]

[a] Combined from the TEXTBITES text message program and created through the co-design workshop

[b] Total text message bank is 131 messages once the introductory and final messages are added, along with 6 messages to encourage communication with health counsellor

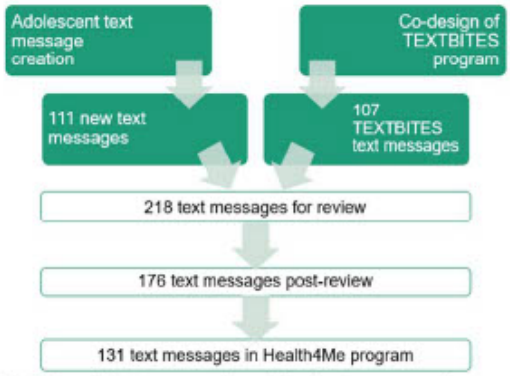

Fig. 1 Flow of text messages through the text message review process

media, body image, mental health and climate change, in addition to nutrition and physical activity [32]. Research also supports these issues as important within an adolescent health context. Emerging research has demonstrated a 'clustering effect', where adolescents who engage in multiple risky lifestyle behaviors have more symptoms of mental illness [34, 35]. The average adolescent today spends 1.6 h per day on social media [36], which is consistently and positively associated with negative body image [37], and the environment was considered the most important issue to 51% of young people across Australia in 2022 [38]. In addition, previous reviews have shown that text message interventions are effective in changing preventive health behaviors [39]. Our co-design process has demonstrated that preventive health care for today's adolescents requires a broader scope and provides direction to address emerging public health issues.

Our research also demonstrated the input required to effectively work with adolescents as co-researchers. Previous preventive health interventions have been tested amongst adolescents, but evidence is lacking to support translation into effective interventions which have been implemented into health services [40]. This study has a strong focus on engaging adolescents to co-design the intervention to produce downstream benefits. Involving adolescents in research about them allows for benefits to the research, the adolescents and to the community [41]. Thus far, adolescents have been involved in three phases of the research, namely: identification of topic, design or development and conduct. Specific to this research, the intervention is co-led by adolescents who identified the key issues for chronic disease prevention [32] and drafted text messages around these issues. Adolescents also advised on recruitment materials to ensure they were appropriate. This potentially has further benefits to the ongoing research, by increasing recruitment and retention of participants and the effectiveness for the intervention in this study. We will conduct a thorough process evaluation to understand these factors when the trial concludes. A separate study evaluated the leadership and life skills of adolescents who were involved in co-designing the intervention (HAPYUS) and found that they improved over 12-months [42]. Finally, there are possible benefits to the wider community, including increased awareness of relevant health issues for adolescents, as has been seen in previous research [43]. By shifting the power to adolescents to co-design the Health4Me intervention, the potential benefits may accelerate the implementation of this research due to its relevance among an adolescent population [41].

There are some more specific learnings from the text message review process, including the importance of striking the right balance in the content of the text messages. In many cases, there was conflicting comments between professionals and adolescents, and even in

some instances between two different groups of adolescents. For example, messages with humor were often seen as 'trying too hard', whereas other adolescents were calling for more humor in the messages. In these cases, it is important to remember who the program is being designed for and to preference the comments of adolescents over those made by professionals, except in the case of evidence-based information. Previous research has shown that adolescents seek lifestyle health information which is credible [44]. This finding was mirrored in this study where messages which scored highly contained links to reputable sources online, and common edits to messages included defining concepts for greater understanding, which often included adding hyperlinks to more information. The review process confirmed the findings of another study, where adolescents preferred messages which referred to them and recommended specific and achievable behaviors [45]. The current study extended this concept, where higher-scoring messages contained practical examples and focused on elements other than just physical health that confirmed experiences of being a young person today.

It is acknowledged that whether these carefully curated messages will result in changes in nutrition and physical activity behaviors is not yet known. The effectiveness of the text message program is currently being tested in a randomized controlled trial (RCT) [22]. The behavior change techniques selected were based on two systematic reviews [4, 29], one of which suggested that parental involvement was a key technique to eliciting significant behavior change. The delivery of this intervention directly to adolescents means that parental involvement could not be addressed, and parental involvement also changes with age as autonomy evolves during adolescence. To acknowledge external supports, we chose to include the behaviour change technique 'plan social support', that has been found useful in interventions for nutrition and physical activity behaviors [46]. Furthermore, adolescents who receive the intervention will also have the option to engage with a health counsellor to provide further support for behavior change using motivational interviewing techniques [47], which have already shown promise in adolescent obesity prevention programs [48, 49]. A detailed evaluation to understand acceptance and engagement with the program through text message software data (delivery, responses, retention rate), quantitative feedback surveys completed by all intervention participants and virtual focus groups with a smaller subset of participants will be part of the RCT [22]. Though adolescents were not consulted on which behaviour change techniques to employ in this study, there is an opportunity for future research to engage with adolescents on this topic to combine the published evidence and views of the intended audience to drive effectiveness and engagement.

There are limitations of this study. Firstly, due to the nature of research and funding cycles, the grant to fund this work was awarded and the youth advisory group set up afterwards. This means that the concept of the project as a text message intervention had already been decided upon before the youth advisory group was assembled. True co-design includes involving consumers through all stages of the development, including the study design [18]. The youth advisory group did not raise any issues with the intervention delivery method, suggesting that the planned research method was acceptable. Secondly, due to recruitment of adolescents for the text message review through convenience sampling, a small number of younger adolescents in Years 7 and 8 (ages 12–13 years) reviewed the text messages, and only one who spoke a language other than English at home. Therefore, there may be a bias for the text message content to be geared toward adolescents aged 15 years and above and potentially be incompatible with culturally and linguistically diverse adolescents and those who are from areas of socioeconomic disadvantage. We have taken steps to mitigate these effects. Firstly, adolescents > 14 years old are able to consent themselves into the randomized controlled trial. This removes the need for parent/guardian consent for this age group, where the parent/guardian may not have proficient English language skills to be able to provide consent but the adolescent does. Secondly, by conducting the Flesch-Kincaid scoring for readability, we ensured the overall text message bank is at a seventh-grade reading level for those who regularly speak and read English.

Conclusion

This study describes the intensive co-design a healthy lifestyle text message intervention, comprised of 131 text messages which are useful, acceptable and engaging for adolescents 12–18 years old. The bank of text messages was developed based on prior research, effective behaviour change techniques for improving nutrition and physical activity behaviours and through adolescent identification of the top lifestyle health issues related to chronic disease prevention (A). This co-designed text message bank is currently being tested for effectiveness in the Health4Me Study. If effective, text message interventions hold potential to be an accessible and affordable method of delivering preventive health information to adolescents to reduce risk of future chronic disease development.

Abbreviations

HAPYUS	The Health Advisory Panel for Youth at the University of Sydney
IRSAD	Index of Relative Socio-economic Advantage and Disadvantage
RCT	Randomized controlled trial

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40900-023-00524-4.

Additional file 1. GRIPP2 Short Form checklist.

Acknowledgements

A special acknowledgement to the Charles Perkins Centre at The University of Sydney for their support of the 2022 in-person workshop. We would also like to acknowledge our partners on the Medical Research Future Fund Primary Care Grant: Australian Cardiovascular Alliance (ACVA) and The Big Feed. The Health Advisory Panel for Youth at the University of Sydney (HAPYUS) is comprised of the following members: Radhika Valanju, Meera Barani, Dominik Mautner, Imeelya Al Hadaya, Alexi Cross, Melani Gunawardana, Ava Lambie, Emily McMahon, Arnav Narula, Bowen Ren, Dominique Rose, Aviral Sharda, Alexander Sinnett, Azman Tanvir, Fulin Yan. The Health4Me Team is comprised of Karice Hyun, Maree L Hackett, Gemma Figtree, Robyn Gallagher, Karen Spielman, Sarah Maguire, Kyra A. Sim, Tim Usherwood, Charlotte Hepse, John Skinner, Liliana Laranjo, Kathryn Williams, Danielle Castles

Author contributions

Conceptualization: RR, JR, SRP; Methodology: RR, JR, SRP; Data collection and analysis: RR, AT, SW, SRP; Writing—original draft preparation: RR, AT, SRP; Writing – reviewing and editing: all authors. All authors have read and agreed to the final version of this manuscript.

Funding

The Health4Me Study is funded by the Australian Government Department of Health Medical Research Future Fund Primary Care Grant (2006315). The funder has no role in the study design, collection, analysis, and interpretation of data or writing of the manuscript. RR is funded by a NHMRC SOLVE-CHD [GNT1182301] Primary and Supplementary Research Scholarship. JR is funded by a NHMRC Investigator Grant (Leadership) (GNT2007946). SRP is supported by a National Heart Foundation Future Leader Fellowship [Grant number: 106646].

Availability of data and materials

Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study received ethics approval from The University of Sydney Human Research Ethics Committee (Approval Number 2022/402). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Received: 30 August 2023 Accepted: 28 November 2023
Published online: 07 December 2023

References

1. Smout S, Gardner LA, Newton N, Champion KE. Dose–response associations between modifiable lifestyle behaviours and anxiety, depression and psychological distress symptoms in early adolescence. Aust N Z J Public Health. 2023;47(1):100010.
2. Holly L, Wong BLH, van Kessel R, Awah I, Agrawal A, Ndili N. Optimising adolescent wellbeing in a digital age. BMJ. 2023;380:e068279.
3. Holly LW, Brian Li H, Agrawal A, Awah I, Azelmat M, Kickbush I, Ndili, N. Opportunities and threats for adolescent wellbeing provided by digital transformations. In Adolescent Well-being: Background Papers for Multi-stakeholder Consultations: Partnership for Maternal Newborn and Child Health (PMNCH); 2021. p. 1–18.
4. Rose T, Barker M, Maria Jacob C, Morrison L, Lawrence W, Strömmer S, Vogel C, Woods-Townsend K, Farrell D, Inskip H, et al. A systematic review of digital interventions for improving the diet and physical activity behaviors of adolescents. J Adolesc Health. 2017;61(6):669–77.
5. Raeside R, Jia SS, Todd A, Hyun K, Singleton A, Gardner LA, Champion KE, Redfern J, Partridge SR. Are digital health interventions that target lifestyle risk behaviors effective for improving mental health and wellbeing in adolescents? A Systematic Review with meta-analyses. Adolesc Res Rev. 2023. https://doi.org/10.1007/s40894-023-00224-w.
6. 9 in 10 Aussie teens now have a mobile. In.: Roy Morgan Research; 2016.
7. Gillian W, Michele PH, Jocelyn S, Ben V, Lisa H. Social media interventions for diet and exercise behaviours: a systematic review and meta-analysis of randomised controlled trials. BMJ Open. 2014;4(2):e003926.
8. Centola D. Social media and the science of health behavior. Circulation. 2013;127(21):2135–44.
9. Dunn AG, Mandl KD, Coiera E. Social media interventions for precision public health: promises and risks. npj Digit Med. 2018;1(1):47.
10. Hall AK, Cole-Lewis H, Bernhardt JM. Mobile text messaging for health: a systematic review of reviews. Annu Rev Public Health. 2015;36:393–415.
11. Barraket J. The digital divide in telepractice service delivery. In. Edited by Studies AIoF. Online; 2021.
12. Teens and Mobile Phones [https://www.pewresearch.org/internet/2010/04/20/teens-and-mobile-phones/]
13. Kang M RF, Sanci L, Steinbeck K, Jan S, Hawke C, Luscombe G, Kong M, Usherwood T. Access 3: young people and the health system in the digital age—final research report. 2018.
14. Ehrenreich S, Beron K, Burnell K, Meter D, Underwood M. How adolescents use text messaging through their high school years: adolescent texting. J Res Adolesc. 2019;30:521–40.
15. United Nations: Convention on the Rights of the Child. In.: General Assembly resolution 44/25; 1990.
16. World Health Organization: youth-centred digital health interventions: a framework for planning, developing and implementing solutions with and for young people. In. Geneva; 2020.
17. Mandoh M, Redfern J, Mihrshahi S, Cheng HL, Phongsavan P, Partridge SR. Shifting from Tokenism to meaningful adolescent participation in research for obesity prevention: a systematic scoping review. Front Public Health. 2021;9:2133.
18. Vargas C, Whelan J, Brimblecombe J, Allender S. Co-creation, co-design, co-production for public health—a perspective on definitions and distinctions. Public Health Res Pract. 2022. https://doi.org/10.17061/phrp3222211.
19. Greenhalgh T, Hinton L, Finlay T, Macfarlane A, Fahy N, Clyde B, Chant A. Frameworks for supporting patient and public involvement in research: Systematic review and co-design pilot. Health Expect. 2019;22(4):785–801.

20. O'Connor S, Hanlon P, O'Donnell CA, Garcia S, Glanville J, Mair FS. Understanding factors affecting patient and public engagement and recruitment to digital health interventions: a systematic review of qualitative studies. BMC Med Inform Decis Mak. 2016;16(1):120.
21. Psihogios AM, Lane-Fall MB, Graham AK. Adolescents are still waiting on a digital health revolution: accelerating research-to-practice translation through design for implementation. JAMA Pediatr. 2022;176(6):545–6.
22. Raeside R, Spielman K, Maguire S, Mihrshahi S, Steinbeck K, Kang M, Laranjo L, Hyun K, Redfern J, Partridge SR, et al. A healthy lifestyle text message intervention for adolescents: protocol for the Health4Me randomized controlled trial. BMC Public Health. 2022;22(1):1805.
23. Redfern J, Thiagalingam A, Jan S, Whittaker R, Hackett ML, Mooney J, De Keizer L, Hillis GS, Chow CK. Development of a set of mobile phone text messages designed for prevention of recurrent cardiovascular events. Eur J Prev Cardiol. 2014;21(4):492–9.
24. Partridge SR, Raeside R, Latham Z, Singleton AC, Hyun K, Grunseit A, Steinbeck K, Redfern J. 'Not to be harsh but try less to relate to "the teens" and you'll relate to them more': co-designing obesity prevention text messages with adolescents. IJERPH. 2019;16(24):4887.
25. Ozer E. Youth-led participatory action research: overview and potential for enhancing adolescent development. Child Dev Perspect. 2017;11:173–7.
26. Partridge SR, Raeside R, Singleton AC, Hyun K, Latham Z, Grunseit A, Steinbeck K, Chow C, Redfern J. Text Message behavioral intervention for teens on eating, physical activity and social wellbeing (TEXTBITES): protocol for a randomized controlled trial. JMIR Res Protocols. 2020;9(2):e16481.
27. 2033.0.55.001—Census of Population and Housing: Socio-Economic Indexes for Areas (SEIFA), Australia, 2016 [https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/2033.0.55.001~2016~Main%20Features~IRSAD~20]
28. Flesch R. A new readability yardstick. J Appl Psychol. 1948;32(3):221–33.
29. Martin J, Chater A, Lorencatto F. Effective behaviour change techniques in the prevention and management of childhood obesity. Int J Obes. 2013;37(10):1287–94.
30. Michie S, Ashford S, Sniehotta FF, Dombrowski SU, Bishop A, French DP. A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: the CALO-RE taxonomy. Psychol Health. 2011;26(11):1479–98.
31. Abraham C, Michie S. A taxonomy of behavior change techniques used in interventions. Health Psychol. 2008;27(3):379–87.
32. Valanju R, Barani M, Mautner D, Al Hadaya I, Cross A, Gunawardana M, Lambie A, McMahon E, Narula A, Ren B, et al. Youth perspective on chronic disease prevention. Lancet Child Adolesc Health. 2022;6(7):456–8.
33. Hickman NE, Schaar G. Impact of an educational text message intervention on adolescents' knowledge and high-risk behaviors. Compr Child Adolesc Nurs. 2018;41(1):71–82.
34. Gardner LA, Champion KE, Chapman C, Newton NC, Slade T, Smout S, Teesson M, Sunderland M. Multiple lifestyle risk behaviours and hierarchical dimensions of psychopathology in 6640 Australian adolescents. Aust New Z J Psychiatry. 2023. https://doi.org/10.1177/00048674221080406.
35. Champion KE, Mather M, Spring B, Kay-Lambkin F, Teesson M, Newton NC. Clustering of multiple risk behaviors among a sample of 18-year-old australians and associations with mental health outcomes: a latent class analysis. Front Public Health. 2018;6:135.
36. Young Women the Queens of social media in Australia [https://www.roymorgan.com/findings/young-women-the-queens-of-social-media-in-australia]
37. Fardouly J, Vartanian LR. Social media and body image concerns: current research and future directions. Curr Opin Psychol. 2016;9:1–5.
38. Mission Australia: Youth Survey Report 2022. In Edited by Leung S, Brennan, N., Freeburn, T., Waugh, W., & Christie, R. Sydney, NSW, Australia; 2022.
39. Armanasco AA, Miller YD, Fjeldsoe BS, Marshall AL. Preventive health behavior change text message interventions: a meta-analysis. Am J Prev Med. 2017;52(3):391–402.
40. Chung RJ, Touloumtzis C, Gooding H. Staying young at heart: cardiovascular disease prevention in adolescents and young adults. Curr Treat Options Cardiovasc Med. 2015;17(12):61.
41. Wilson O, Daxenberger L, Dieudonne L, Eustace J, Hanard A, Krishnamurthi A, Quigley P, Vergou A. A rapid evidence review of young people's involvement in health research. In Edited by Wellcome. London, United Kingdom; 2020.
42. Mandoh M, Raeside R, Todd A, Redfern J, Mihrshahi S, Cheng HL, Phongsavan P, Partridge SR. Empowering adolescents in chronic disease prevention research: mixed-methods evaluation of a 12-month youth advisory group. BMC Public Health. 2023;23:2344.
43. Findholt NE, Michael YL, Davis MM. Photovoice engages rural youth in childhood obesity prevention. Public Health Nurs. 2011;28(2):186–92.
44. Raeside R, Jia SS, Redfern J, Partridge SR. Navigating the online world of lifestyle health information: qualitative study with adolescents. JMIR Pediatr Parent. 2022;5(1):e35165.
45. Hingle M, Nichter M, Medeiros M, Grace S. Texting for health: the use of participatory methods to develop healthy lifestyle messages for teens. J Nutr Educ Behav. 2013;45(1):12–9.
46. Draper CE, Grobler L, Micklesfield LK, Norris SA. Impact of social norms and social support on diet, physical activity and sedentary behaviour of adolescents: a scoping review. Child Care Health Dev. 2015;41(5):654–67.
47. Bundy C. Changing behaviour: using motivational interviewing techniques. J R Soc Med. 2004;97(Suppl 44):43–7.
48. Flattum C, Friend S, Neumark-Sztainer D, Story M. Motivational interviewing as a component of a school-based obesity prevention program for adolescent girls. J Am Diet Assoc. 2009;109(1):91–4.
49. Walpole B, Dettmer E, Morrongiello BA, McCrindle BW, Hamilton J. Motivational interviewing to enhance self-efficacy and promote weight loss in overweight and obese adolescents: a randomized controlled trial. J Pediatr Psychol. 2013;38(9):944–53.

Publisher's Note

Appendix 1: GRIPP2 Short Form checklist

Section and Topic	Item	Reported on page no.
1. Aim	Report the aim of PPI[a] in the study	p.143
2. Methods	Provide a clear description of the methods used for PPI in the study	p.143-144
3. Study results	Outcomes—Report the results of PPI in the study, including both positive and negative outcomes	p.144-148
4. Discussion and conclusions	Outcomes—Comment on the extent to which PPI influenced the study overall. Describe positive and negative effects	p.146, 148-149
5. Reflections/critical perspective	Comment critically on the study, reflecting on the things that went well and those that did not, so others can learn from this experience	p.149

[a]*PPI* patient and public involvement

Chapter One

Introduction

Chapter Two

Systematic Review with Meta-Analysis

Chapter Three

Qualitative Study with Adolescents

HEALTH4ME

Chapter Four

Co-Design of Health4Me

Chapter Five

Health4Me RCT Protocol

Chapter Six

Health4Me Recruitment

Chapter Seven

Qualitative Study with Stakeholders

Chapter Eight

Discussion and Conclusions

CHAPTER FIVE: A healthy lifestyle text message intervention for adolescents: protocol for the Health4Me randomized controlled trial

Preface to the Chapter

Chapter Four provided evidence of engaging adolescents to identify the six top health issues for young people today in relation to chronic disease intervention and to co-design a text message intervention that is useful, acceptable, and engaging for an adolescent audience. This chapter (Chapter Five) presents the published protocol of the Health4Me randomised controlled trial titled 'A healthy lifestyle text message intervention for adolescents: protocol for the Health4Me randomized controlled trial', thereby addressing Aim 5 of this thesis. Good Clinical Practice and Motivtional Interviewing training certificates are available in Appendix A. Ethics approvals and participant information and consent forms for this study are presented in Appendix C. In addition, all questionnaires collected as a part of this study are available in Appendix D. This protocol paper has undergone expedited peer review due to being Category A funded and ethics approval received (submitted 12th September 2022, accepted 14th September 2022) and published (23rd September 2022) in *BMC Public Health.* A correction was published (20th February 2024) as the original publication had the incorrect sample size. Authors contributions to this paper are outlined in the authorship attribution statement. Chapter Five was disseminated in the following ways:

Published peer reviewed manuscript

Raeside R, Spielman K, Maguire S, Mihrshahi S, Steinbeck K, Kang M, Laranjo L, Hyun K, Redfern J, Partridge SR, The Health4Me Team. A Healthy Lifestyle Text Message Intervention for Adolescents: Protocol for the Health4Me Randomized Controlled Trial. *BMC Public Health* 2022; 22:1805. https://doi.org/10.1186/s12889-022-14183-9

Author attribution statement

This statement is to stipulate the contribution of Rebecca Raeside in the preparation and submission of the following manuscript: ‘A healthy lifestyle text message intervention for adolescents: protocol for the Health4Me randomized controlled trial‘. The convention is that the author with the principal contribution to the study is the first author.

Rebecca Raeside, during her PhD candidature, developed the concept for the study, was responsible for designing and refining the study protocol, intervention and data collection instruments, drafted and managed the ethics submission, organised trial registration with the Australia and New Zealand Clinical Trials Registry, drafted the manuscript and subsequent revisions and coordinated submission for publication.

The individual roles of co-authors are listed below:

TASK	ROLE OF CO-AUTHORS
STUDY CONCEPTUALISATION	RR, SRP
DESIGNING THE RCT	RR, SRP
REFINING THE RESEARCH QUESTION	ALL
STUDY METHODOLOGY	ALL
REFINING THE ANALYSIS PLAN	RR, KH, SRP
DRAFTING MANUSCRIPT	RR
REVISION AND CRITICAL COMMENTS ON MANUSCRIPT	ALL
MANUSCRIPT SUBMISSION	RR

Rebecca Raeside 26 Sept 2024

As supervisor for the candidature upon which this thesis is based, I can confirm that the author attribution statement above is correct.

Dr Stephanie Partridge 26 Sept 2024

Raeside et al. BMC Public Health (2022) 22:1805
https://doi.org/10.1186/s12889-022-14183-9

BMC Public Health

STUDY PROTOCOL Open Access

A healthy lifestyle text message intervention for adolescents: protocol for the Health4Me randomized controlled trial

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Abstract

Background: Adolescence presents a window of opportunity to establish good nutrition and physical activity behaviours to carry throughout the life course. Adolescents are at risk of developing cardiovascular and other chronic diseases due to poor the complex interplay of physical and mental health lifestyle risk factors. Text messaging is adolescents main form of everyday communication and text message programs offer a potential solution for support and improvement of lifestyle health behaviours. The primary aim of this study is to determine effectiveness of the Health4Me text message program to improve adolescent's physical activity or nutrition behaviours among adolescents over 6-months, compared to usual care.

Methods: Health4Me is a virtual, two-arm, single-blind randomised controlled trial, delivering a 6-month healthy lifestyle text message program with optional health counselling. Recruitment will be through digital advertising and primary care services. In total, 330 adolescents will be randomised 1:1 to intervention or control (usual care) groups. The intervention group will receive 4–5 text messages per week for 6-months. All text messages have been co-designed with adolescents. Messages promote a healthy lifestyle by providing practical information, health tips, motivation and support for behaviour change for physical activity, nutrition, mental health, body image, popular digital media and climate and planetary health. Virtual assessments will occur at baseline and 6-months assessing physical health (physical activity, nutrition, body mass index, sleep), mental health (quality of life, self-efficacy, psychological distress, anxiety, depression, eating disorder risk) and lifestyle outcomes (food insecurity and eHealth literacy).

Discussion: This study will determine the effectiveness of a 6-month healthy lifestyle text message intervention to improve physical activity and nutrition outcomes in adolescents.

Trial registration: Australia New Zealand Clinical Trials Registry (ANZCTR) ACTRN12622000949785, Date registered: 05/07/2022.

Keywords: Adolescent, Prevention, Physical activity, Nutrition, mHealth, Text message, Randomized controlled trial

Introduction

Adolescence presents a window of opportunity to establish good nutrition and physical activity behaviours, which are the pillars of overall future physical and mental health [1]. However, the current picture of adolescent physical and mental health worldwide is concerning.

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Research has established associations between several lifestyle risk factors, including physical activity, nutrition, sedentary behaviour and sleep that are contributing to the declining physical and mental health status of adolescents [2, 3]. Adolescents in high income countries, like Australia are not meeting national guidelines for these risk factors. National Australian data from 2017 to 18 and 2011–12 found 96% of adolescents do not meet national guidelines for fruit and vegetable intake [4], and 41% of their total energy intake came from discretionary foods [5], respectively. Globally more than 80% of adolescents are not engaged in sufficient physical activity [6]. Reducing sedentary behaviour is important for both physical and mental health. However, Australian data from 2017 to 18 found only 7.9% of 13–17-year olds met the physical activity guideline, and only 20% met the sedentary screen-based behaviour guideline [7]. Short sleep duration amongst adolescents is also prevalent. For example, in a sample of American students, 6 out of 10 middle school students and 7 out of 10 high school students were not sleeping for the recommended 8–10 hours per night [8]. The COVID-19 pandemic negatively impacted the lifestyle behaviours Australian adolescents. Cross-sectional data from a sample of 983 adolescents indicated increases of excessive recreational screen time (86 to 94%) and insufficient fruit intake (20 to 30%). As well, this data indicated proportions of adolescents engaging in insufficient physical activity (82%) and vegetable intake (84%) remained concerning [3]. The intersection of risk factors for both obesity and mental health demonstrates the need for holistic programs which provide support to improve lifestyle risk factors.

Systematic reviews have shown that poor nutrition, physical inactivity, sedentary behaviour and sleep are all linked to poor mental health [9–11] and to obesity [12, 13]. Globally, the presence of overweight and obesity among children and adolescents 5–19 years has risen from 4% in 1975 to over 18% in 2016 [14]. By 2030 it is predicted there will be 254 million children and adolescents with obesity [15]. National Australian data from 2017 to 18 found 25% of children and adolescents 2–17 years have overweight or obesity [16]. Similarly, the period of adolescence is the highest risk developmental stage for the onset of mental illness [17]. In adolescents it has been shown that there is a bi-directional association between overweight and obesity and poor mental health [18, 19]. Overweight and obesity during adolescence has immediate impacts on quality of life [20], which if not addressed may have long term consequences on well-being [21]. Research has also demonstrated significant links of unhealthy diets to mental health in adolescence [9, 22]. Adolescent mental health is of growing concern with 14% of 10–19-year-olds globally experiencing a mental disorder with depression, anxiety and behavioural disorders among the leading causes of illness and disability [1]. In Australia, 20% of adolescents aged 12–17 had high or very high levels of psychological distress and 14% experienced a mental disorder [23]. The COVID-19 pandemic has also significantly disrupted the lives of Australian adolescents, with research showing a worsening in mental health [24], with the potential for long-term impacts [25]. Failing to address mental health conditions in adolescence can harm physical and mental health and hinder leading a fulfilling life in adulthood [1], displaying a growing need for action in these areas.

The current approach to improving the health behaviours of adolescents needs to be aligned with best practice recommendations [26]. Programs that target mental health often do not focus on nutrition and physical activity behaviours [27] and programs with an obesity prevention or management lens can be stigmatizing [28]. There is a need to develop accessible and scalable programs which focus on prevention through management of lifestyle health behaviours and mindful of impacts on mental health. This is in line with the Australian National Obesity Strategy 2022–32 where young people recognised the need for holistic approaches to support a healthy lifestyle [29]. Recent research has shown that the primary care health setting in Australia is appropriate for delivering preventive care to adolescents [30]. However, the barriers to primary care services are bi-directional, adolescents cite barries including cost of visits, opening hours, transport to and from services, concerns about confidentiality and feeling embarrassed [31]. General practitioners (GPs) have indicated that time is a major barrier as adolescents often need longer consultations to build strong relationships and overcome communication barriers to deliver lifestyle health information [30]. Therefore, for prevention programs to be effective, these barriers must also be addressed so that adolescents are empowered to improve their lifestyle health behaviours.

The ubiquitous nature of mobile health (mHealth) programs offers a potential solution to address these risks. There is strong evidence supporting the efficacy of text messaging in adults for facilitating positive behaviour change for physical activity [32], nutrition [33], mental health [34] and management of cardiovascular disease risk [35]. A systematic review assessing text messaging as an intervention for adolescent physical activity and sedentary behaviour found that there was high heterogeneity of study design which prevented conclusions as to which intervention elements were linked to increased effectiveness, and therefore concluded that further research is needed with text messaging as the focus of the intervention to demonstrate the effect of text messages on these lifestyle health behaviours [36]. Text messaging is well

suited to adolescents as 94% of adolescents in Australia own a mobile phone [37], text messaging is their main form of communication and direct communication can be made with participants for minimal cost. Text messaging also improves accessibility to programs from those in rural, remote, and disadvantaged populations who have inequitable access to healthcare and where the COVID-19 pandemic has only increased these inequities [38]. There is a need for simple and accessible solutions that focus on prevention, specifically targeting physical and mental health among adolescents.

The primary aim of this study is to determine, in a single blind randomized controlled trial (RCT), whether a semi-personalised text message healthy lifestyle program (Health4Me) compared to usual care will improve adolescents' physical activity (moderate to vigorous physical activity [MVPA] minutes per day) or nutrition (vegetable intake >3 serves per day) behaviours among adolescents over 6-months. Further, to determine if the text message program can improve or maintain other physical and mental health and lifestyle outcome, to explore the acceptability, utility and engagement with Health4Me among youth and inform implementation into primary health care services in Australia.

Methods

Study design

The Health4Me study is a virtual, randomised, controlled, single-blind trial, which delivers a 6-month text message healthy lifestyle program with optional health counselling to 330 healthy adolescents (12–18 years old inclusive) (Fig. 1).

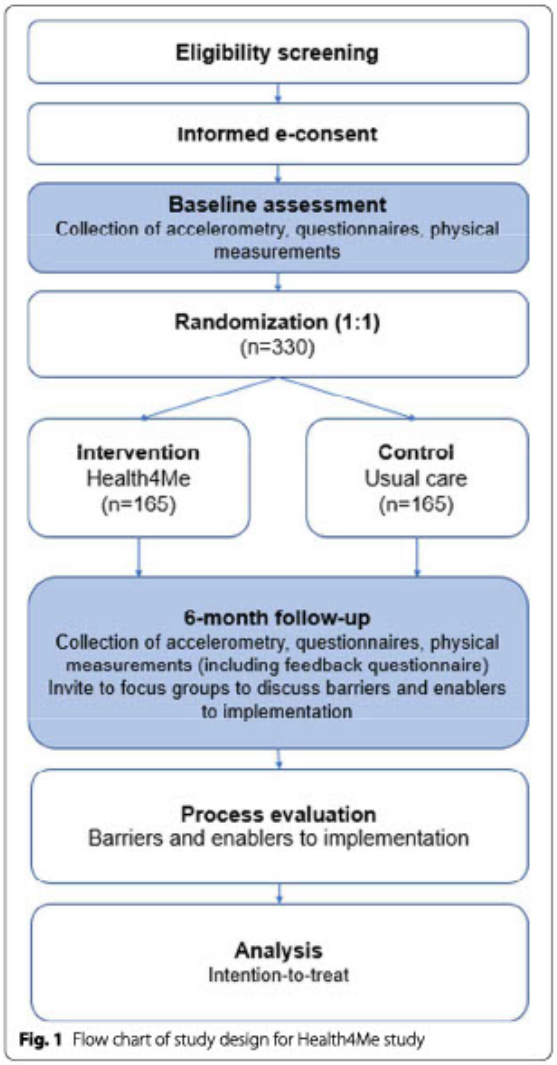

Fig. 1 Flow chart of study design for Health4Me study

Randomization and blinding

Participants will be randomly allocated to either the intervention or control group. The control group will receive usual care (no intervention). Participants will view digital advertisements for the study on social media, after clicking on a link it will take them to the participant information sheet which they can read and provide informed e-consent. After obtaining electronic consent from adolescents (and their parents or guardians if <14 years old) and completing the baseline assessment on a secure web-based database, a member of the research team will randomize the participant via a centralized, computerized randomisation program in a uniform 1:1 allocation ratio (intervention: control). Randomization is based on both permuted blocks with randomized block sizes and stratification, where the strata are age and gender. A randomization list will be generated by an independent statistician. Members of the research team who enrol and conduct follow-ups with participants will be blinded to group allocation.

For each participant, the randomization program automatically produces a study identification number. On the following Monday after the baseline assessment, the computer system automatically sends the assigned text message program to the participant. Therefore, the random allocation sequence will be concealed from study personnel at baseline and at 6-months. Participants will be encouraged not to discuss whether they are or are not receiving the text messages until the end of the 6-month follow-up.

Study population

As the study is virtual, there are no physical sites for recruitment. Rather, participants will be recruited through digital advertisements. GPs will also be informed of the study via email and encouraged to advertise this to their adolescent patients. A log of all recruitment strategies will be kept. Participants will be eligible to take part if they are: (1) 12–18 years old inclusive; (2) own a mobile phone capable of sending and receiving text messages; (3) have sufficient English to read text messages pitched at a 7th grade reading level; and (4) provide electronic consent (or from their parents or guardians if < 14 years old).

Participants will be excluded if they: (1) have a diagnosis of type 1 or type 2 diabetes mellitus; (2) have a previous or current diagnosis of an eating disorder or are at high risk for an eating disorder as assessed in screening; (3) weight < 25th centile for age; (4) have had recent rapid weight loss; (5) have a medical condition which would preclude providing informed consent or ability to comply with the study protocol; (6) are enrolled in an alternative randomised lifestyle management program; (7) are pregnant or planning to become pregnant during the 6-month intervention; and (8) are unable to read English at a 7th grade reading level. Screening will occur for eating disorders at baseline, 2, 4 and 6-months and any participant who scores above the pre-determined threshold will trigger the study team to refer appropriately. Both screening and recruitment logs will be kept by the research team for those participants who are ineligible or decline to participate, including reasons for non-participation.

Control group

The control group will receive usual care. For this study, usual care is defined as accessing available information and health services to maintain a healthy lifestyle. Participants in the control group receive an initial text message welcoming them to the study, and one text message at 2, 4 and 6 months respectively. The messages at 2 and 4 months will have a link to complete the eating disorder screening and the message at 6 months will direct them to complete all follow-up assessments. Participants in the control group will be offered the text message intervention after the 6-month follow-up assessments are complete at no cost. However, they will not be able to receive health counselling.

Intervention group

The intervention group will receive usual care, plus a 6-month text message support program with text messages focussed over six key priority areas for improving physical and mental health, namely nutrition, physical activity, mental health, body image, climate and planetary health and popular digital media (e.g., social media), as well as the option to speak with a university-trained health counsellor.

Message content

Message program content was developed according to a previously published model [39]. Briefly, an established youth advisory group (comprised of 16 adolescents aged 13 to 18 years old inclusive) identified current top health issues for young people [40] and assisted in drafting relevant and practical content, informed by national physical activity, dietary and sedentary screen-based behaviour guidelines, behaviour change theories and lived experience of being a young person in today's world. Furthermore, text messages will also include information on how the primary care system works and how to connect with primary care services, including GPs. Included in the bank of text messages is one welcome message and one final text message. Each message will have a unique signature as the study name to ensure that participants know these messages are from the research study and participants at enrolment will be told how to unsubscribe if required.

Message frequency and sequence

Each intervention participant will receive a semipersonalized and customized set of text messages, sent on four random days per week and at random times. If the participant is attending high school, the weekday text messages will only be sent before or after school hours (8.00 AM to 9.00 AM or 3.30 PM to 7.30 PM). Each text message is unique and will only be sent once throughout the 6-month program. The messages are semipersonalized by including the participants name and selecting content relevant to their age and dietary behaviours (e.g., vegetarian). Participants can also update their key information, (e.g., change in dietary behaviours) through the course of the study and this will be reflected in the ongoing text messages they receive. Messages are sent at no cost to the participants and a bulk-rate cost to the study. However, if participants reply to the study team, these will be paid for by the participant at standard short message service (SMS) rates. The intervention will encourage two-way communication; however, it is for the participant to decide how much they engage with the study. All replies and responses are monitored by the health counsellor and responses given in 72 hours when required.

Health counsellor

Once a month (6 in total), intervention participants will be sent a text message encouraging them to call the university qualified health counsellor to ask questions or request additional information. The personalised health counselling calls will last 10–15 minutes and will be

delivered according to standardized protocol. The university qualified health counsellor (allied health or public health professional) will monitor and respond to participants' request for a call each month either via text message or phone call within 3 working days. Participants are allowed 6 health counselling calls in total over 6-months. The health counselling calls will allow participants to set behavioural goals, discuss barriers and enablers to behaviour change, and their overall progress. This part of the intervention is based on the evidence based TEXTBITES Study for obesity prevention in adolescents [41].

Text message management system

The text message management system has been used successfully in two randomised controlled trials (TEXTBITES and EMPOWER-SMS) [42, 43]. Pre-specified algorithms are put in place to ensure that the intervention group are the only ones who receive the Health4Me message program. Each week, messages are randomly selected from the text message bank by the software system such that a variety of messages are delivered each week from the four key priority areas. Both groups are sent a welcome message at the beginning of the study and a concluding message after 6-months. Participants are instructed in the welcome message to save the dedicated number that the text messages come from, so that they are not seen as spam. They are also given details on how to unsubscribe from the messages if required. All participants receive information on safe and acceptable times to read text messages (e.g. not to read messages while driving) and contact details of the research team in case of any issues. A member of the research team will manage a study mobile phone, and a record is kept of all incoming messages from participants and outgoing messages from the health counsellor. Analysis of incoming and outgoing messages will be performed at the end of the study, as part of the process evaluation. If a participant from either group wishes to withdraw from the study, they can at any time by replying 'STOP' to any of the messages or contacting the research team. If a reason for withdrawal is provided, it will be recorded in the enrolment log.

Data collection and study outcomes

Data will be collected from participants at baseline and 6-months online. In addition, for safety the eating disorder screening will be conducted at 2-months and 4-months for all participants. The co-primary outcomes, secondary outcomes and their assessments are provided below in Table 1. Multiple endpoints have been selected such that a significant effect against either one may be taken as evidence of efficacy. The co-primary outcomes are change in moderate-to-vigorous minutes of physical activity (MVPA) minutes per day and change in the proportion of participants meeting vegetable intake guidelines (>3 serves per day). MVPA will be measured by ActivInsights Geneactiv wrist-worn accelerometers [46]. After enrolment and at the 6-month assessment, participants will be mailed an accelerometer to wear for 7 days

Table 1 Description of Health4Me study outcomes and assessments

Outcome	Assessment
Dual Primary Outcomes	
Vegetable intake	Australian Child and Adolescent Eating Survey [ACAES] [44, 45]
Moderate-vigorous physical activity (MVPA) min/day	Geneactiv activity and sleep unit worn for 7 days [46]
Secondary Outcomes	
BMI[a] *z*-score	Units BMI is above or below average for the age- and sex-specific reference values, using participant self-reported weight and height [47]
Waist-to-height ratio	Mid measure between the iliac crest and lowest rib and height, using participant self-reported waist circumference and height [47]
Dietary quality	Australian Child and Adolescent Eating Survey [ACAES] [44, 45]
Sleep quality	Pittsburgh Sleep Quality Index Short [PSQI-Short] [48, 49]
Health-related quality of life	Child Health Utility instrument [CHU9D] [50]
Self-efficacy	Self-efficacy for Healthy Eating and Physical Activity [SE-HEPA] [51]
Anxiety	General Anxiety Disorder-7 [GAD-7] [52]
Depression	Centre for Epidemiological Studies Depression Scale Revised-10 [CESDR-10] [53]
Psychological distress	Kessler Psychological Distress Scale [K6] [54]
Eating disorder risk	InsideOut Institute screening tool [IOI-S] [55]
Food insecurity	USDA[b] 6-item food security module [56]
eHealth literacy	eHEALS eHealth Literacy Scale [57]

[a] *BMI* Body mass index

[b] *USDA* United States Department of Agriculture

and then return by pre-paid post to the research team. Vegetable intake will be measured using data from the Australian Child and Adolescent Eating Survey (ACAES), developed by the University of Newcastle [44].

Weight, height and waist circumference will be self-reported by participants according to a standardised digital protocol [47]. Participants will be shown how to correctly measure weight, height and waist circumference by videos put together by the research team and embedded into the data collection form. Self-reported height and weight has been validated amongst young adults in an Australian population [58–60]. Weight, height and waist circumference measurements will be used to calculate BMI z-score (using age and sex specific reference values) and waist-to-height ratio.

The following questionnaire-based assessments have demonstrated reliability and validity in adolescent populations and will be completed online at baseline and follow-up assessments. Sleep quality will be measured using the Pittsburgh Sleep Quality Index-Short [48, 49]. Health related quality of life and self-efficacy will be measured by the Child Health Utility Instrument (CHU9D) [50] and Self Efficacy for Healthy Eating and Physical Activity (SE-HEPA) [51] respectively. Anxiety, Depression and Psychological Distress will be measured by the General Anxiety Disorder-7 (GAD-7) [52], Centre for Epidemiological Studies Depression Scale Revised-10 (CESDR-10) [53] and the Kessler Psychological Distress Scale (K6) [54]. Eating disorder risk will be measured using the InsideOut Institute screening tool (IOI-S) [55]. Food insecurity will be measured with the USDA 6-item food security module [56] and eHealth literacy with eHEALS eHealth Literacy Scale [57]. A schedule of enrolment, interventions and assessments is presented in Table 2. All data will be entered electronically into Research Electronic Data Capture (REDCap), hosted on secure servers by the University of Sydney. Electronic data will be monitored by the research team through monthly reports to ensure quality and completeness of the data.

Table 2 Health4Me study schedule of enrolment and assessments

Assessments	Pre-baseline	Baseline	6-month follow-up
Enrolment			
Eligibility screen	✓		
Informed consent	✓		
Randomisation		✓	
Assessments			
Demographics		✓	
Physical activity		✓	✓
Dietary intake		✓	✓
BMI[a] z-score		✓	✓
Waist-to-height ratio		✓	✓
Sleep quality		✓	✓
Quality of life		✓	✓
Self-efficacy		✓	✓
Anxiety		✓	✓
Depression		✓	✓
Psychological distress		✓	✓
Eating disorder risk		✓	✓
Food insecurity		✓	✓
eHealth literacy		✓	✓
Process evaluation			✓

[a] *BMI* Body mass index

Process measures

The acceptability, utility and engagement with the Health4Me Program will be measured through quantitative and qualitative measures. Firstly, text message data will be extracted from the software system to assess engagement by the number of messages sent, number of responses received, and number of messages 'bounced' and undelivered. Secondly, a study-specific user feedback and satisfaction questionnaire will be administered to all participants. It will contain questions on a 5-point Likert scale from strongly agree to strongly disagree regarding acceptability and utility of the program. It will also include open ended questions regarding most and least useful program components and suggestions for program improvement. These responses will be coded thematically, and emerging themes identified. The questionnaire will also ask questions about whether participants used or accessed any other digital health tools to help manage their lifestyle health behaviours during the study. Intervention participants will be invited by text message, email, or phone call to join focus groups after the 6-month follow-up. A minimum of five focus groups will be conducted consecutively until thematic saturation is reached. The focus groups will be conducted via Zoom teleconference and last approximately 45 minutes. Participants will be purposively selected to ensure a mix in terms of age, ethnicity and location are represented to encompass different viewpoints.

Statistical considerations

For the outcome of MVPA (minutes per day), 312 (156 per group) participants are needed to achieve 90% power to observe the mean difference of 14.8 (control: 42.55 and intervention: 57.36) with standard deviations (SD) of 21.45 for control and 37.79 for intervention and accounting for 30% dropout. A two-sided two-sample unequal-variance t-test was used. The Bonferroni adjusted significance level of 0.025 was used to account for two

primary outcomes. To detect a difference in vegetable intake at 6-months, 390 (195 per group) participants will achieve 90% power to detect 13.37% difference in the proportion of appropriate vegetable consumption (control: 4.85% and intervention: 18.22%) and accounting for 30% dropout [61]. The two-sided Z-Test with unpooled variance was used with the significance level of the test is 0.025. Therefore, a sample size of 390 will allow the detection of the change in MVPA or vegetable intake.

All statistical analyses will follow a pre-specified statistical analysis plan guided by our team statistician. Analyses of the primary and secondary outcomes will be conducted according to the intention-to-treat principle. Continuous outcomes at 6-months will be analysed using analysis of covariance (ANCOVA), and categorical outcomes at 6-months will be analysed using log-binomial regression, adjusting for the outcome values at baseline. Planned subgroup analyses will investigate interactions between treatment and subgroups, including categories of age, socioeconomic status and ethnicity, to explore trends for scale up. All tests will be two-sided with a significance level of 0.05. Analyses of the two primary outcomes will be controlled for the family-wise error rate using Holm correction [62]. No multiplicity adjustments will be performed for secondary outcomes as they are exploratory analyses. The analyses will be performed using SAS (V9.4 SAS Institute Inc. Cary NC, USA).

Ethics approval and consent

Primary ethics approval has been received from the University of Sydney Human Research Ethics Committee (2022/402). Any modifications to the protocol will be submitted to the ethics committee. E-consent will be collected from all participants (and their parents or guardians if < 14-years-old). The sponsor for the study is the University of Sydney and they have no role in the study design, collection, management, analysis and interpretation of data, the writing of findings or submission of findings for publication. The design and conduct and dissemination of the study will be overseen by the Health4Me steering committee (named authors and the Health4Me Team).

Discussion

Current obesity prevention approaches are ineffective and there are limited programs beyond the school setting available which suit the needs of adolescents, coupled with an escalating mental health crisis for young people in Australia. Positively framed prevention programs which focus on good nutrition and physical activity behaviours can address both critical issues and these programs must be accessible for adolescents. This study aims to provide information and support for lifestyle risk factors by developing and testing a 6-month text message primary prevention program for adolescents in an RCT. It is expected that the results will include improvements or maintenance in primary and secondary outcomes. If effective, this study will inform future translational research to improve the physical and mental health of adolescents and prevent the future development of chronic diseases in adulthood and implementing such a program into healthcare services throughout Australia. Results from the process measures will identify barriers and enablers of widespread implementation of the text message program, with the goal of providing accessible and accurate lifestyle health information and support to adolescents to establish lifelong healthy behaviours.

Conclusion

This study will test the effectiveness of a 6-month text message intervention to improve and support the physical and mental health outcomes of all adolescents. This study will also provide information on the barriers and enablers of the text message program and ways in which it can be improved. If effective, the results will provide high quality evidence to inform future translational research to scale up the program and embed it within healthcare systems throughout Australia.

Abbreviations

ANCOVA: Analysis of covariance; BMI: Body Mass Index; COVID-19: Coronavirus disease of 2019; GPs: General Practitioners; MVPA: Moderate to Vigorous Physical Activity; RCT: Randomized Controlled Trial; SD: Standard Deviation; SMS: Short Message Service.

Acknowledgments

A special acknowledgement to the Health Advisory Panel for Youth at the University of Sydney 2021/22 (HAPYUS 2021/22), without whom this research would not be possible (Radhika Valanju, Meera Barani, Dominik Mautner, Imeelya Al Hadaya, Alexi Cross, Melani Gunawardana, Ava Lambie, Emily McMahon, Arnav Narula, Bowen Ren, Dominique R, Aviral Sharda, Alexander Sinnett, Azman Tanvir and Fulin Yan).

An acknowledgement to Ms. Emma Bryant from the InsideOut Institute for her assistance in developing the dedicated eating disorder screening pathways and cut off points for this study.

Health4Me Team comprises the following investigators: Maree L Hackett, Gemma Figtree, Robyn Gallagher, Kyra A Sim, Tim Usherwood, Charlotte Hepse, John Skinner, Katrina E Champion, Lauren A Gardner, Kathryn Williams and Danielle Castles. The entire Health4Me Team plus named authors comprises the Steering Committee.

Sponsor

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Authors' contributions

Conceptualisation: RR and SP; methodology: RR, KS (1), SM (1) and SP; writing – original draft preparation: RR; writing – reviewing and editing: all authors. All authors have read and agreed to the final version of this manuscript.

Funding
The Health4Me Study is funded by the Australian Government Department of Health Medical Research Future Fund Primary Care Grant (2006315). The funder has no role in the study design, collection, analysis, and interpretation of data or writing of the manuscript.
RR is supported by a CSANZ Research Scholarship and SOLVE-CHD Supplementary Scholarship. KH is supported by NHMRC Investigator Grant (Emerging Leadership 1) [APP1196724]. JR is supported by a NHMRC Investigator Grant Level 2 [GNT2007946]. SRP is supported by a National Health and Medical Research Council and National Heart Foundation Early Career Fellowship [APP1157438].

Availability of data and materials
Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Primary ethics approval has been received from the University of Sydney Human Research Ethics Committee (2022/402). E-consent will be collected from all participants (and their parents or guardians if < 14-years-old).

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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Received: 12 September 2022 Accepted: 14 September 2022
Published online: 23 September 2022

References

1. World Health Organization: Adolescent mental health https://www.who.int/news-room/fact-sheets/detail/adolescent-mental-health Accessed 13 July 2022.
2. Champion KE, Chapman C, Gardner LA, Sunderland M, Newton NC, Smout S, et al. Lifestyle risks for chronic disease among Australian adolescents: a cross-sectional survey. Med J Aust. 2022;216(3):156–7.
3. Gardner LA, Debenham J, Newton NC, Chapman C, Wylie FE, Osman B, et al. Lifestyle risk behaviours among adolescents: a two-year longitudinal study of the impact of the COVID-19 pandemic. BMJ Open. 2022;12(6):e060309.
4. ABS. National Health Survey: First Results, 2017–18. In: Australian Bureau of Statistics; 2018.
5. ABS. Australian health survey: nutrition and physical activity 2011-12. In: Australian Bureau of Statistics; 2013.
6. World Health Organization: Physical activity. https://www.who.int/news-room/fact-sheets/detail/physical-activity. Accessed 13 July 2022.
7. Australian Institute of Health and Welfare. Physical activity across the life stages. Canberra: AIHW; 2018.
8. Wheaton AGJS, Cooper AC, Croft JB. Short Sleep Duration Among Middle School and High School Students — United States, 2015. MMWR Morb Mortal Wkly Rep. 2018;67:85–90.
9. O'Neil A, Quirk SE, Housden S, Brennan SL, Williams LJ, Pasco JA, et al. Relationship between diet and mental health in children and adolescents: a systematic review. Am J Public Health. 2014;104(10):e31–42.
10. Rodriguez-Ayllon M, Cadenas-Sánchez C, Estévez-López F, Muñoz NE, Mora-Gonzalez J, Migueles JH, et al. Role of physical activity and sedentary behavior in the mental health of preschoolers, children and adolescents: a systematic review and meta-analysis. Sports Med. 2019;49(9):1383–410.
11. Sampasa-Kanyinga H, Colman I, Goldfield GS, Janssen I, Wang J, Podinic I, et al. Combinations of physical activity, sedentary time, and sleep duration and their associations with depressive symptoms and other mental health problems in children and adolescents: a systematic review. Int J Behav Nutr Phys Act. 2020;17(1):72.
12. Fatima Y, Doi SAR, Mamun AA. Longitudinal impact of sleep on overweight and obesity in children and adolescents: a systematic review and bias-adjusted meta-analysis. Obes Rev. 2015;16(2):137–49.
13. Rey-López JP, Vicente-Rodríguez G, Biosca M, Moreno LA. Sedentary behaviour and obesity development in children and adolescents. Nutr Metab Cardiovasc Dis. 2008;18(3):242–51.
14. World Health Organization: Obesity and overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight. Accessed 13 July 2022.
15. World Obesity Federation. Atlas of Childhood Obesity. https://www.worldobesity.org/membersarea/global-atlas-on-childhood-obesity. Accessed 13 July 2022.
16. AIHW. Overweight and obesity among Australian children and adolescents. Canberra: Australian Institute of Health and Welfare; 2020.
17. Solmi M, Radua J, Olivola M, Croce E, Soardo L, Salazar de Pablo G, et al. Age at onset of mental disorders worldwide: large-scale meta-analysis of 192 epidemiological studies. Mol Psychiatry. 2022;27(1):281–95.
18. van Vuuren CL, Wachter GG, Veenstra R, Rijnhart JJM, van der Wal MF, Chinapaw MJM, et al. Associations between overweight and mental health problems among adolescents, and the mediating role of victimization. BMC Public Health. 2019;19(1):612.
19. Kansra AR, Lakkunarajah S, Jay MS. Childhood and Adolescent Obesity: A Review. Front Pediatr. 2021;8:581461. https://doi.org/10.3389/fped.2020.581461.
20. Killedar A, Lung T, Petrou S, Teixeira-Pinto A, Tan EJ, Hayes A. Weight status and health-related quality of life during childhood and adolescence: effects of age and socioeconomic position. Int J Obes. 2020;44(3):637–45.
21. Martinson ML, Vasunilashorn SM. The long-arm of adolescent weight status on later life depressive symptoms. Age Ageing. 2016;45(3):389–95.
22. Oddy WH, Robinson M, Ambrosini GL, O'Sullivan TA, de Klerk NH, Beilin LJ, et al. The association between dietary patterns and mental health in early adolescence. Prev Med. 2009;49(1):39–44.
23. Australian Institute of Health and Welfare. Mental illness. Canberra: AIHW; 2021.
24. Li SH, Beames JR, Newby JM, Maston K, Christensen H, Werner-Seidler A. The impact of COVID-19 on the lives and mental health of Australian adolescents. Eur Child Adolesc Psychiatry. 2022;31(9):1465-77. https://doi.org/10.1007/s00787-021-01790-x.
25. Australian Institute of Health and Welfare. COVID-19 and the impact on young people. Canberra: AIHW; 2021.
26. Partridge SR, Reece L, Sim KA, Todd A, Jia SS, Raeside R, et al. An analysis of current obesity strategies for adolescents in NSW against best practice recommendations: implications for researchers, policymakers and practitioners. Health Promot J Austr. 2022; Online ahead of print.
27. Rosenbaum S, Tiedemann A, Stanton R, Parker A, Waterreus A, Curtis J, et al. Implementing evidence-based physical activity interventions for people with mental illness: an Australian perspective. Australas Psychiatry. 2015;24(1):49–54.
28. Falkner NH, Neumark-Sztainer D, Story M, Jeffery RW, Beuhring T, Resnick MD. Social, educational, and psychological correlates of weight status in adolescents. Obes Res. 2001;9(1):32–42.

29. Department of Health. National Obesity Strategy 2022–2032. Canberra: Australian Government; 2021.
30. Kang M, Robards F, Luscombe G, Sanci L, Usherwood T. The relationship between having a regular general practitioner (GP) and the experience of healthcare barriers: a cross-sectional study among young people in NSW, Australia, with oversampling from marginalised groups. BMC Fam Pract. 2020;21(1):220.
31. Kang MRF, Sanci L, Steinbeck K, Jan S, Hawke C, Luscombe G, et al. Access 3: young people and the health system in the digital age - final research report; 2018.
32. Hurling R, Catt M, Boni MD, Fairley BW, Hurst T, Murray P, et al. Using internet and mobile phone technology to deliver an automated physical activity program: randomized controlled trial. J Med Internet Res. 2007;9(2):e7.
33. Santo K, Hyun K, de Keizer L, Thiagalingam A, Hillis GS, Chalmers J, et al. The effects of a lifestyle-focused text-messaging intervention on adherence to dietary guideline recommendations in patients with coronary heart disease: an analysis of the TEXT ME study. Int J Behav Nutr Phys Act. 2018;15(1):45.
34. Cox KL, Allida SM, Hackett ML. Text messages to reduce depressive symptoms: do they work and what makes them effective? A systematic review. Health Educ J. 2020;80(3):253–71.
35. Chow CK, Redfern J, Hillis GS, Thakkar J, Santo K, Hackett ML, et al. Effect of lifestyle-focused text messaging on risk factor modification in patients with coronary heart disease: a randomized clinical trial. JAMA. 2015;314(12):1255–63.
36. Ludwig K, Arthur R, Sculthorpe N, Fountain H, Buchan DS. Text messaging interventions for improvement in physical activity and sedentary behavior in youth: systematic review. JMIR mHealth uHealth. 2018;6(9):e10799.
37. Roy Morgan Research: 9 in 10 Aussie teens now have a mobile . http://roymorgan.com.au/findings/6929-australian-teenagers-and-their-mobile-phones-june-2016-201608220922. Accessed 13 July 2022.
38. Sutherland K, Chessman J, Zhao J, Sara G, Shetty A, Smith S, et al. Impact of COVID-19 on healthcare activity in NSW, Australia. Public Health Res Pract. 2020;30(4):e3042030.
39. Redfern J, Thiagalingam A, Jan S, Whittaker R, Hackett ML, Mooney J, et al. Development of a set of mobile phone text messages designed for prevention of recurrent cardiovascular events. Eur J Prev Cardiol. 2014;21(4):492–9.
40. Valanju R, Barani M, Mautner D, Al Hadaya I, Cross A, Gunawardana M, et al. Youth perspective on chronic disease prevention. Lancet Child Adolesc Health. 2022;6(7):456–8.
41. Partridge SR, Raeside R, Singleton AC, Hyun K, Latham Z, Grunseit A, et al. Text message behavioral intervention for teens on eating, physical activity and social wellbeing (TEXTBITES): protocol for a randomized controlled trial. JMIR Res Protocols. 2020;9(2):e16481.
42. Singleton A, Partridge SR, Raeside R, Regimbal M, Hyun KK, Chow CK, et al. A text message intervention to support women's physical and mental health after breast cancer treatments (EMPOWER-SMS): a randomised controlled trial protocol. BMC Cancer. 2019;19(1):660.
43. Singleton AC, Raeside R, Partridge SR, Hyun KK, Tat-Ko J, Sum SCM, et al. Supporting women's health outcomes after breast cancer treatment comparing a text message intervention to usual care: the EMPOWER-SMS randomised clinical trial. J Cancer Surviv. 2022; Online ahead of print.
44. Watson JF, Collins CE, Sibbritt DW, Dibley MJ, Garg ML. Reproducibility and comparative validity of a food frequency questionnaire for Australian children and adolescents. Int J Behav Nutr Phys Act. 2009;6(1):62.
45. Burrows TL, Warren JM, Colyvas K, Garg ML, Collins CE. Validation of overweight children's fruit and vegetable intake using plasma carotenoids. Obesity (Silver Spring). 2009;17(1):162–8.
46. Vanl CMT, Okely AD, Batterham MJ, Hinkley T, Ekelund U, Brage S, et al. Wrist acceleration cut points for moderate-to-vigorous physical activity in youth. Med Sci Sports Exerc. 2018;50(3):609–16.
47. Lohman TRA, Martorell R. In: Kinetics H, editor. Anthropometric Standardization Reference Manual. Champaign: Human Kinetics Books, Chicago; 1988.
48. de la Vega R, Tomé-Pires C, Solé E, Racine M, Castarlenas E, Jensen MP, et al. The Pittsburgh sleep quality index: validity and factor structure in young people. Psychol Assess. 2015;27(4):e22–7.
49. Famodu OA, Barr ML, Holásková I, Zhou W, Morrell JS, Colby SE, et al. Shortening of the Pittsburgh sleep quality index survey using factor analysis. Sleep Disord. 2018;2018:9643937.
50. Ratcliffe J, Stevens K, Flynn T, Brazier J, Sawyer M. An assessment of the construct validity of the CHU9D in the Australian adolescent general population. Qual Life Res. 2012;21(4):717–25.
51. Steele MM, Burns LG, Whitaker BN. Reliability and validity of the SE-HEPA: examining physical activity– and healthy eating–specific self-efficacy among a sample of preadolescents. Health Educ Behav. 2013;40(3):355–61.
52. Tiirikainen K, Haravuori H, Ranta K, Kaltiala-Heino R, Marttunen M. Psychometric properties of the 7-item generalized anxiety disorder scale (GAD-7) in a large representative sample of Finnish adolescents. Psychiatry Res. 2019;272:30–5.
53. Haroz EE, Ybarra ML, Eaton WW. Psychometric evaluation of a self-report scale to measure adolescent depression: the CESDR-10 in two national adolescent samples in the United States. J Affect Disord. 2014;158:154–60.
54. Mewton L, Kessler RC, Slade T, Hobbs MJ, Brownhill L, Birrell L, et al. The psychometric properties of the Kessler psychological distress scale (K6) in a general population sample of adolescents. Psychol Assess. 2016;28(10):1232–42.
55. Bryant E, Miskovic-Wheatley J, Touyz SW, Crosby RD, Koreshe E, Maguire S. Identification of high risk and early stage eating disorders: first validation of a digital screening tool. J Eat Disord. 2021;9(1):109.
56. Blumberg SJ, Bialostosky K, Hamilton WL, Briefel RR. The effectiveness of a short form of the household food security scale. Am J Public Health. 1999;89(8):1231–4.
57. Norman CD, Skinner HA. eHEALS: the eHealth literacy scale. J Med Internet Res. 2006;8(4):e27.
58. Davies A, Wellard-Cole L, Rangan A, Allman-Farinelli M. Validity of self-reported weight and height for BMI classification: a cross-sectional study among young adults. Nutrition (Burbank, Los Angeles County, Calif). 2020;71:110622.
59. Sarkkola C, Rounge TB, Simola-Ström S, von Kraemer S, Roos E, Weiderpass E. Validity of home-measured height, weight and waist circumference among adolescents. Eur J Pub Health. 2016;26(6):975–7.
60. (CDC) CDCaP: measuring children's height and weight accurately at home; 2021.
61. Cullen KW, Thompson D, Boushey C, Konzelmann K, Chen TA. Evaluation of a web-based program promoting healthy eating and physical activity for adolescents: teen choice: food and fitness. Health Educ Res. 2013;28(4):704–14.
62. Holm S. A simple sequentially rejective multiple test procedure. Scand J Stat. 1979;6(2):65–70.

Publisher's Note

BMC Public Health

CORRECTION

Open Access

Correction: A healthy lifestyle text message intervention for adolescents: protocol for the Health4Me randomized controlled trial

Rebecca Raeside[1*], Karen Spielman[2], Sarah Maguire[2,3], Seema Mihrshahi[4], Katharine Steinbeck[5,6], Melissa Kang[7], Liliana Laranjo[8,9], Karice Hyun[1,10], Julie Redfern[1,11], Stephanie R. Partridge[1,12] and the Health4Me Team

Correction: BMC Public Health 22, 1805 (2022)
https://doi.org/10.1186/s12889-022-14183-9

The original publication of this article contained an incorrect sample size. The incorrect sample size was 330, the correct sample size is 390. The authors have submitted an updated ethical amendment which has been approved. This does not impact the conclusions of the article. The original article has been updated to correct all instances of 330 to 390.

Published online: 20 February 2024

The original article can be found online at https://doi.org/10.1186/s12889-022-14183-9.

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Reference

1. Rebecca R, et al. A healthy lifestyle text message intervention for adolescents: protocol for the Health4Me randomized controlled trial. BMC Public Health. 2022;22:1805. https://doi.org/10.1186/s12889-022-14183-9.

Appendix 1: SPIRIT Checklist for Health4Me Protocol

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Chapter One

Introduction

Chapter Two

Systematic Review with Meta-Analysis

Chapter Three

Qualitative Study with Adolescents

HEALTH4ME

Chapter Four

Co-Design of Health4Me

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Chapter Six

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CHAPTER SIX: Recruitment of adolescents to virtual clinical trials: recruitment results from the Health4Me randomized controlled trial

Preface to the Chapter

Chapter Five provided the clinical trial protocol for the Health4Me Randomised Controlled Trial (RCT). This chapter (Chapter Six) presents the findings from the recruitment of participants to the Health4Me RCT titled 'Recruitment of Adolescents to Virtual Clinical Trials: Recruitment Results From the Health4Me Randomized Controlled Trial', thereby addressing Aim 6 of this thesis. The manuscript that forms this chapter has been formatted for *JMIR Pediatrics and Parenting* (submitted 5th June 2024, resubmitted with corrections following reviewer comments 23rd September 2024) and has been accepted (11th October 2024) and published (16th December 2024). Authors' contributions to this paper are outlined in the author attribution statement. Good Clinical Practice Certifications are presented in Appendix A. Ethics approval, participant information and consent forms and recruitment materials for this study are presented in Appendix C. Screening questionnaires used in this study are presented in Appendix D. Chapter Six was disseminated in the following ways:

Published peer reviewed manuscript

Raeside R, Todd AR, Barakat S, Rom S, Boulet S, Maguire M, Williams K, Mihrshahi S, Hackett ML, Redfern J, Partridge SR and The Health4Me Team. Recruitment of Adolescents to Virtual Clinical Trials: Recruitment Results From the Health4Me Randomized Controlled Trial. *JMIR Pediatrics and Parenting* 2024;7:e62919. doi: 10.2196/62919.

Conference presentations

1. **Raeside R** et al (17-19/09/2024) Is social media effective for recruiting adolescents to the Health4Me RCT? 6-min oral. Public Health Association of Australia, Australian Public Health Conference 2024, Perth, Australia.

Author attribution statement

This statement is to stipulate the contribution of Rebecca Raeside in the preparation and submission of the following manuscript: ‘Recruitment of adolescents to virtual clinical trials: recruitment results from the Health4Me randomized controlled trial‘. The convention is that the author with the principal contribution to the study is the first author.

Rebecca Raeside, during her PhD candidature, developed the concept for the study, was responsible for designing the RCT, refined the research question, decided on study methodology, conducted all analyses, drafted the manuscript and subsequent revisions and coordinated submission for publication.

The individual roles of co-authors are listed below:

TASK	ROLE OF CO-AUTHORS
STUDY CONCEPTUALISATION	RR
DESIGNING THE RCT	RR, SRP
REFINED THE RESEARCH QUESTION	ALL
STUDY METHODOLOGY	ALL
CONDUCTED ANALYSES	RR, AT
DRAFTED MANUSCRIPT	RR
REVISION AND CRITICAL COMMENTS ON MANUSCRIPT	ALL
MANUSCRIPT SUBMISSION	RR

Rebecca Raeside 26 Sept 2024

As supervisor for the candidature upon which this thesis is based, I can confirm that the author attribution statement above is correct.

Dr Stephanie Partridge 26 Sept 2024

Original Paper

Recruitment of Adolescents to Virtual Clinical Trials: Recruitment Results From the Health4Me Randomized Controlled Trial

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Abstract

Background: Preventive interventions are needed to provide targeted health support to adolescents to improve health behaviors. Engaging adolescents in preventive interventions remains a challenge, highlighting the need for innovative recruitment strategies. Given adolescents' lives are intertwined with digital technologies, attention should be focused on these avenues for recruitment. The evolving nature of clinical trials, including the emergence of virtual clinical trials, requires new recruitment approaches, which must be evaluated.

Objective: This study aimed to examine the effectiveness and cost of various digital recruitment strategies for recruiting adolescents to a virtual clinical trial, evaluate the progression of participants from screening to enrollment, and explore factors associated with nonparticipation. This was conducted using data from the Health4Me Study, a preventive digital health intervention to improve physical activity and nutrition behaviors among adolescents aged 12 to 18 years.

Methods: Participants were recruited into the Health4Me Study via social media advertisements on various contemporary platforms, emails to schools, emails to contacts within known networks, and emails to relevant youth organizations. Data were collected from social media advertisements, screening, and recruitment logs. Data analysis included summary and descriptive statistics, as well as chi-square tests to explore factors associated with nonparticipation.

Results: From 2369 expressions of interest, 390 (16.4%) participants were enrolled. A total of 19 advertisements were placed on social media, and 385 promotional emails were sent to schools, contacts within known networks, and relevant youth organizations. Social media advertisements reached 408,077 unique accounts. Advertisements mostly reached those living in populous states in Australia (306,489/408,077, 75.11% of unique accounts) and those identifying as female (177,698/408,077, 43.55% of unique accounts). A total of 24.97% (101,907/408,077) of advertisements were delivered to accounts with uncategorized genders. The total cost per participant enrolled was Aus $3.89 (approximately US $2.58). Most participants (1980/2305, 85.90%) found out about this study through Instagram. Differences in screening characteristics between eligible participants

who did and did not enroll were found to be statistically significant for gender (P=.02), with fewer males and more individuals reporting their gender as "other" enrolling than expected by chance alone. The recruitment method also differed (P<.001), with fewer participants enrolling through Instagram and more enrolling through other methods (eg, known networks or word of mouth) than expected by chance alone.

Conclusions: This study found that virtual clinical trial recruitment was found to be low-cost, with the potential to increase trial participation. Social media was the most effective recruitment method, reaching all states and territories, including hard-to-reach populations. Future action is needed to explore recruitment methods that are more effective for males and to build trust among adolescents regarding clinical trial recruitment via social media.

Trial Registration: Australia New Zealand Clinical Trials Registry ACTRN12622000949785; https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=383576&isReview=true

JMIR Pediatr Parent 2024;7:e62919; doi: 10.2196/62919

Keywords: adolescents; clinical trial; recruitment; digital health; prevention; adolescent health; health behavior change; health promotion; social media

Introduction

Adolescence is regarded as the second window of opportunity—a critical period to intervene and provide targeted support to improve health outcomes that have a profound impact on health and well-being throughout the life course [1]. Failure to invest in primary prevention among today's adolescents will increase the burden of chronic diseases and the existing sizable total health expenditure of Aus $24 billion (approximately US $15.9 billion) on potentially avoidable risk factors [2]. It is important that high-quality public health interventions that focus on primary prevention of chronic diseases are tested with adolescents through clinical trials. However, challenges exist with engaging adolescents in preventive interventions, including their health system disengagement making them hard to access for delivering such interventions [3], a prevention lens not being appealing to adolescents [4], and their evolving need for autonomy in providing informed consent [5]. Innovative methods to engage adolescents within preventive interventions are needed that can overcome identified barriers.

Adolescents' lives are increasingly intertwined with digital technologies such as mobile phones and the internet [6]. With that comes the opportunity to harness developments in digital technologies for innovative preventive interventions [7]. The use of digital methods for recruitment to clinical trials is increasing in popularity and they are particularly beneficial for recruitment to online clinical trials. Previous research has focused on comparing social media or other digital strategies to traditional in-person recruitment [8-13], and the use of digital tools for recruitment and retention of clinical trial participants [14,15]. While research shows that digital recruitment strategies are effective compared to traditional in-person recruitment, limited research is available to understand the efficiency of digital recruitment strategies alone and their impact on clinical trial participants and investigators (eg, helping investigators identify eligible trial participants) [14]. A previous review identified that Facebook (Meta) is effective for recruiting adolescent participants [16], and a cross-sectional study revealed that the use of Instagram (Instagram from Meta) and Snapchat (Snap Inc) may also be useful and cost-effective to recruit young people to surveys [17], but limited evidence is available for the use of these contemporary platforms for adolescent recruitment to clinical trials. As more social media platforms become available and others diminish in popularity, it is crucial that research is undertaken to understand their effectiveness for recruiting adolescents to research.

Additional complexities occur when there are no physical recruitment sites, otherwise known as remote [18], decentralized [19], or virtual [20] clinical trials, from hereon in called virtual clinical trials. Virtual clinical trials can leverage digital technologies for participant recruitment and retention, enabling online consent for participants, on-time data collection, and delivery of the intervention that is convenient for participants, as they do not have to travel to a physical site [21]. Virtual clinical trials among adolescent participants have the potential to overcome some of the previously identified barriers, including reaching those who are disengaged with the health system and reaching adolescents directly [22,23], allowing them autonomy in making decisions about their health [24], including providing informed consent (depending on ethics approvals). However, there is limited research to understand digital recruitment strategies for clinical trials among adolescents. Furthermore, it is also important to understand factors that may cause eligible participants not to engage in digital preventive interventions. Reporting will enable future research to tailor recruitment toward the most effective digital strategies and address factors that cause disengagement. Therefore, this study aimed (1) to examine the effectiveness and cost of various digital recruitment strategies for recruiting adolescents to a virtual clinical trial, (2) to evaluate the progression of participants from screening to enrollment, and (3) explore factors associated with nonparticipation.

Methods

Study Design

The Health4Me study was used as the context for this research. The full protocol is published elsewhere [25]. In brief, the Health4Me Study is a virtual clinical trial, based in Australia, of a community-based, 6-month text message intervention. The intervention aims to improve physical

activity and nutrition behaviors among adolescents aged 12 to 18 years.

Ethical Considerations

Primary ethics approval was received from the University of Sydney Human Research Ethics Committee (2022/402), and the trial is registered at the Australia New Zealand Clinical Trials Registry (ANZCTR; ACTRN12622000949785; date registered: July 5, 2022).

Participants and Eligibility Criteria

Participants were eligible to take part in the Health4Me Study if they were (1) aged 12 to 18 years, (2) owned a mobile phone capable of sending and receiving text messages, (3) had an Australian mobile phone number, (4) had sufficient English proficiency to read text messages pitched at a 7th grade reading level, and (5) provided electronic consent (or from their parents or guardians if they were aged <14 years). Participants were excluded from this study if they (1) had a diagnosis of type 1 or type 2 diabetes mellitus, (2) had a previous or current diagnosis of an eating disorder or were at high risk for an eating disorder as assessed in screening, (3) weighed <25th centile for their age, (4) had recent rapid weight loss, (5) had a medical condition that would preclude providing informed consent or ability to comply with this study's protocol, (6) were enrolled in an alternative randomized lifestyle management program, (7) were pregnant or planning to become pregnant during the 6-month intervention, and (8) were unable to read English at a 7th grade reading level. The eligibility criteria for the Health4Me Study have been published elsewhere [25].

Given the Health4Me Study was conducted virtually, several steps were embedded to ensure participants could safely enroll into this study. To complete screening procedures, the research team partnered with the InsideOut Institute for Eating Disorders, a team of researchers and clinician experts in eating disorders based at the University of Sydney. Potential participants first expressed interest to take part in this study by filling out the Expression of Interest (EOI) form on REDCap (Research Electronic Data Capture; Vanderbilt University), which included contact details and screening against the eligibility criteria, as well as screening for eating disorder risk using two validated questionnaires—InsideOut Institute Screener (IOI-S) and Eating Disorder Examination Questionnaire (EDE-Q) [26,27]. Study specific cut points were set for the IOI-S (≥16) and EDE-Q (>3 and any of behavioral questions 15-18 endorsed ≥1). Potential participants first completed the IOI-S, if they scored below the cut point and met all inclusion criteria, they were sent the e-consent form. However, if participants scored above the cut point on the IOI-S, they were directed to complete an EDE-Q. If potential participants scored under the cut point on the EDE-Q, they were deemed eligible and sent the e-consent form. If a potential participant was detected to be above the cut point on the EDE-Q, they were referred to the InsideOut Institute for Eating Disorders for an assessment to determine suitability to participate by eating disorder expert clinicians (clinical psychologist or registered clinical psychology students with expertise in eating disorders) via phone call. If they received clearance from the eating disorder expert clinicians, they were sent the e-consent form and deemed eligible to enroll in this study. If they did not receive clearance, they were sent an email with various resources for eating disorder support. If a potential participant did not meet other inclusion criteria, they were sent an email explaining why they were ineligible. All participants provided informed e-consent (and from their parents or guardians if they were aged <14 years) before baseline measures were collected [25]. Participants were randomized once all baseline measures were complete.

Recruitment

The protocol was to enroll 390 participants—195 per arm—based on detecting a mean difference in moderate to vigorous physical activity minutes per day of 14.8 (control: 42.55 and intervention: 57.36) with an SD of 21.45 for control and 37.79 for intervention or a 13.37% difference in the proportion of appropriate vegetable consumption (control: 4.85% and intervention: 18.22%) with 90% power and accounting for 30% dropout. The Bonferroni adjusted significance level of 0.025 was used to account for two primary outcomes. The participant information statement detailed that participants would receive an Aus $30 (approximately US $19.90) gift voucher at the completion of all baseline assessments as a reimbursement for their time. A recent review has suggested that financial incentives can be provided to children appropriately, and few studies suggest incentives are inherently harmful [28]. Recruitment methods are detailed below.

Recruitment Methods

Overview

Recruitment ran from February 2023 to February 2024 using a range of methods including social media advertising on Facebook, Instagram, TikTok, and Twitter/X, emails to schools, emails to contacts within known networks, and emails to relevant youth organizations. A dedicated study website was also created to establish legitimacy.

Social Media Advertisements

Initially, study-dedicated Facebook and Instagram pages were established with this study's logo, study contact information and detailed the purpose of this study. Posts were made on Instagram to establish this study as an authentic and active social media account. All content and this study logo were co-designed with adolescents [29]. All advertisements were created using ethics approved text and images on Meta Ads Manager, which simultaneously promoted advertisements on Facebook and Instagram or on TikTok for Business, which promoted advertisements on TikTok. Due to restrictions in advertising to people aged younger than 18 years [30], all advertisements were targeted only for people aged 13 to 18 years in Australia. Examples of the social media advertisements (images and text) are available in Multimedia Appendix 1. Advertisements on Meta were run for a maximum of 2 weeks, with a maximum budget of Aus $20 (approximately US $13.30) per day. The single advertisement on TikTok was run for 4 days, with a lifetime budget of Aus

$50 (approximately US $33.20). A single post was made on Twitter/X by a member of the research team. All advertisements linked directly to this study EOI form, hosted on REDCap.

Emails

Emails were sent to schools, known networks and contacts of the research team and, relevant youth organizations, for example, headspace. Emails contained a link to this study's website and this study's REDCap page.

Study Website

Previous formative work by the research team revealed that adolescents desire online health information that is credible and reliable [31]. A study website was created to establish this study as legitimate and to build trust among adolescents. This study's website contained this study's logo, study contact information, detailed the purpose of this study, how to become involved (including a direct link to this study's REDCap page), photographs and names of the key researchers and names of the wider research team. Potential participants could also access the full participant information sheet through this study's website.

Data Sources

Social Media Advertisements

Data were available and collected from Meta Ads Manager. For each advertisement, data were collected on the number of days the advertisement ran, advertisement strategy used, reach, impressions, link clicks, cost per result, and total amount spent (Aus $). Deidentified advertisement audience demographic data included location, age, and gender. User's location was based on their state or territory (New South Wales [NSW], Victoria, South Australia, Queensland, Western Australia, Northern Territory, Tasmania, and Australian Capital Territory). Age and gender data were based on what social media users disclose on their user profiles and were summarized according to Meta Ads Manager categories (age: 13-17 or 18-24 years; gender: male, female, or uncategorized). Data were available and collected from TikTok for Business. For each advertisement, data were collected on the number of days the advertisement ran, reach, impressions, link clicks, cost per result, and total amount spent (Aus $). Post analytics were available and collected from Twitter/X. For the single post, data were collected on likes, reposts, impressions, and link clicks.

Recruitment Log

A log was kept of all dates on which emails were sent to schools, known networks and contacts, and youth organizations. Data were also collected on the number of people who visited this study's REDCap page each day to express interest and the number of enrollments. Detailed notes were kept on the log by the research team.

Screening Logs

A detailed log was kept of all participant inquiries. The secure online REDCap [32] database collected data, including age (12-14 years or 15-18 years), gender (male, female, other, or prefer not to say), high school attendance (yes or no), height and weight (for BMI calculations, categorized as underweight, healthy weight, above a healthy weight, or well above a healthy weight) [33,34], and recruitment method. The responses for recruitment method included (1) Facebook, (2) Instagram, (3) Twitter/X, (4) TikTok, (5) other social media platform, (6) headspace, (7) general practitioner or doctor, and (8) other. The screening log also contained details on eligibility and reasons for exclusion. A further screening log was also collected from the InsideOut Institute for Eating Disorders, which kept a detailed log of potential participants requiring screening for eating disorder risk. The secure online REDCap database allowed both the psychologists and research team to make comments. Potential participants were contacted a maximum of two times by the eating disorder expert clinicians. If contact was not established after two attempts, they were marked as ineligible and sent resources via email.

Data Analysis

Summary statistics regarding social media data are presented. Total costs (Aus $) are reported for social media advertisements, with the average cost calculated per participant eligible and per participant enrolled. Descriptive statistics for continuous measures, including counts and percentages for recruitment method, were used to summarize the breakdown of potential participants who inquired and participants screened by the InsideOut Institute for Eating Disorders.

To explore factors associated with nonparticipation, differences in screening characteristics between eligible participants who did and did not enroll in this study were compared using chi-square tests. The significance level was set at 5%. Characteristics included age, gender, BMI, high school attendance, and recruitment method. Adjusted standardized residuals (ASRs) were used to measure the strength of the difference between observed and expected values. Data were analyzed using IBM SPSS (version 29.0; IBM Corp).

Results

Effectiveness and Cost of Recruitment Strategies

A total of 2369 entries were made to the EOI form. Of those, 2305 respondents completed the question asking how they heard about this study. Most (1980/2305, 85.90%) found out about this study through Instagram, followed by other (182/2305, 7.9%) and then Facebook (112/2305, 4.9%). The full sample size of 390 adolescents was reached in 12 months.

For the Health4Me Study, there were 17 advertisements run on Meta Ads Manager over 12 months. The length at which the advertisements were running for ranged from 2-18 days, with advertisements running for a total of 146 days. Overall, advertisements reached a total of 408,077 unique Meta accounts and were viewed >2.3

million times. A cost-per-link-click strategy was employed in 16/17 advertisements, and one employed a cost-per-post-engagement strategy. Across 17 advertisements, 7211 link clicks were made. Advertisements mostly reached people in NSW, Victoria, and Queensland, accounting for 75.11% (306,489/408,077) of the audience. With regard to age, 96.89% (395,403/408,077) of the advertisement audience was 13-17 years old. For gender, advertisements mostly reached females (43.55%, 177,698/408,077); however, a quarter (24.97%, 101,907/408,077) of the advertisements were delivered to accounts with uncategorized genders. One advertisement was run through TikTok for Business, which ran for 4 days, reached 8386 unique accounts, and was viewed 14,832 times, with 144 link clicks made. No further data were available. One advertisement was placed on Twitter/X, which was viewed a total of 1041 times and reposted 11 times, with 15 link clicks made.

The overall cost of social media advertisements run through Meta was Aus $1478.63 (approximately US $965.69). Cost-per-link-click ranged from Aus $0.03 to Aus $0.87 (approximately US $0.02 to US $0.54). The overall cost of the advertisement through TikTok was Aus $39.97 (approximately US $26.10), with cost-per-link-click at Aus $0.28 (approximately US $0.18). In total, Aus $1518.60 (approximately US $991.80) was spent on social media advertisements. Cost per eligible participant was Aus $1.64 (approximately US $1.09), and cost per participant enrolled was Aus $3.89 (approximately US $2.58). A full breakdown of all social media data is available in Tables 1 and 2.

Emails requesting inclusion in school communications to students were sent to 367 high schools across NSW. One school announced this study at their school assembly. One email was sent to our mailing list of young people who have expressed interest in future research. Emails were sent to 17 other known networks, contacts, and youth organizations. Of those, the research team was made aware that one shared in their general practitioner newsletter, and one shared within their local health district. All sharing through schools, known networks, contacts, and youth organizations was at no cost to the research team.

Table 1. Breakdown of Meta advertisements reach by state or territory, age, and gender.

	Reach, n (%)
State or territory	
New South Wales	123,543 (30.27)
Victoria	95,954 (23.51)
Queensland	86,992 (21.32)
Western Australia	44,808 (10.98)
South Australia	31,814 (7.8)
Northern Territory	5633 (1.38)
Tasmania	9858 (2.42)
Australian Capital Territory	5377 (1.32)
Unknown	4098 (1)
Age (years)	
13-17	395,403 (96.89)
18-24	12,674 (3.11)
Gender	
Female	177,698 (43.55)
Male	128,472 (31.48)
Uncategorized	101,907 (24.97)
Total	408,077 (100)

Table 2. Breakdown of social media advertisements for the Health4Me study through Meta, TikTok, and Twitter/X.

Social media platform and advertisement start date	End date	Days advertisements live (n)	Advertisement strategy[a]	Reach[b]	Impressions[c]	Total cost (Aus $[d])	Daily budget (Aus $)	Link clicks[e] (n)	Cost per result (Aus $)	Post reactions (n)	Post saves (n)	Post shares (n)
Meta (Instagram and Facebook)												
February 10, 2023	February 28, 2023	18	Post engagement	14,128	36,340	112.96	10	68	0.03	3184	5	1
March 2, 2023	March 8, 2023	6	Link clicks	88,929	138,404	59.87	10	550	0.11	28	4	17
March 31, 2023	April 15, 2023	16	Link clicks	70,992	164,879	115.66	10	675	0.17	76	5	19
April 28, 2023	May 12, 2023	15	Link clicks	86,464	237,153	143.3	10	775	0.18	106	6	22
May 16, 2023	May 28, 2028	13	Link clicks	93,409	237,016	123.73	10	641	0.19	78	2	9
May 31, 2023	June 14, 2023	15	Link clicks	117,056	345,260	144	10	680	0.21	208	1	9
June 15, 2023	June 30, 2023	15	Link clicks	110,532	307,182	162.05	10	706	0.23	127	1	10
July 4, 2023	July 18, 2023	14	Link clicks	96,816	301,837	143.73	10	664	0.22	69	3	8
July 21, 2023	July 25, 2023	4	Link clicks	72,945	124,063	80.86	20	731	0.11	113	13	23
July 28, 2023	July 31, 2023	4	Link clicks	64,672	99,327	59.77	20	410	0.15	66	7	8
September 1, 2023	September 4, 2023	4	Link clicks	49,600	76,721	59.99	20	375	0.16	41	6	9
October 13, 2023	October 16, 2023	4	Link clicks	44,795	72,066	59.99	20	435	0.14	51	7	14
November 23, 2023	November 25, 2023	3	Link clicks	18,484	18,995	40	20	72	0.56	3	0	3
December 1, 2023	December 3, 2023	3	Link clicks	35,278	36,989	41.18	20	85	0.48	0	0	0
January 16, 2024	January 21, 2024	6	Link clicks	8185	13,463	62.74	15	103	0.61	3	0	3
February 2, 2024	February 5, 2024	4	Link clicks	15,311	19,940	44.35	15	51	0.87	10	1	1
February 22, 2024	February 23, 2024	2	Link clicks	114,365	134,196	24.45	20	190	0.13	61	1	0
Totals	N/A[f]	146	N/A	408,077	2,363,831	1478.63	N/A	7211	N/A	4224	62	156
TikTok												
August 25, 2023	August 29, 2023	4	N/A	8386	14,832	39.97	10	144	0.28	7	0	0
Twitter												
February 14, 2024	N/A	N/A	N/A	N/A	1041	0	0	15	0	15	0	11

[a]Post engagement: strategy aims to encourage users to like, share, comment on, or save the advertisement. Link clicks: strategy aims to encourage users to click on the advertisement URL link.
[b]Number of times the advertisement is delivered to a unique account.
[c]Number of times the advertisement is delivered in total (including being delivered multiple times to one account).
[d]The conversion rate over the time of the study was approximately Aus $1=US $0.65.
[e]Number of times the advertisement URL link was clicked.
[f]N/A: not applicable.

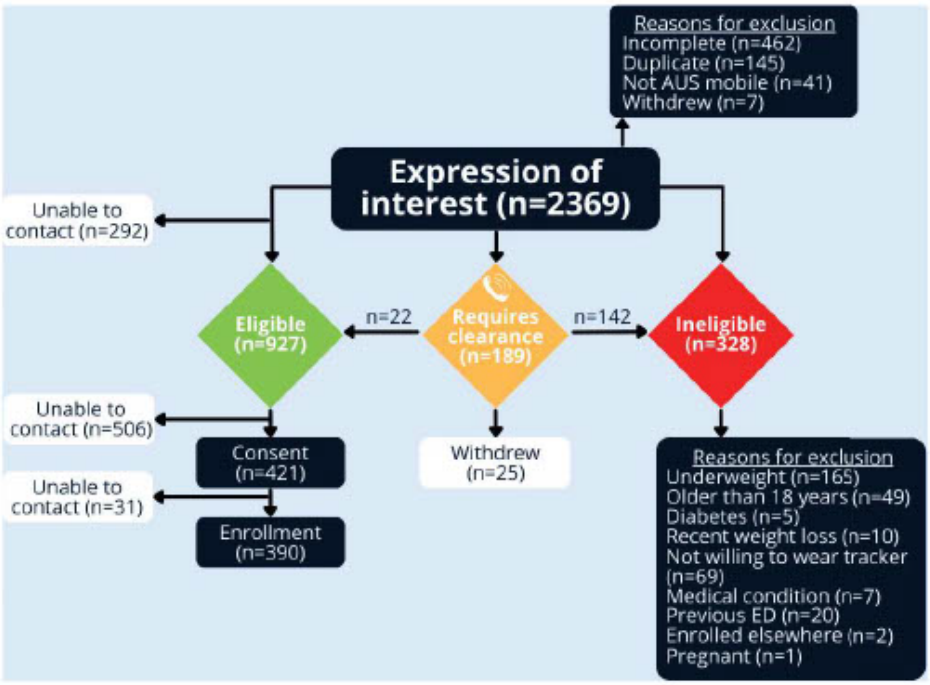
Progression of Participants From Screening to Enrollment

Figure 1 shows the progression of participants and dropout points from screening to enrollment. Of the 2369 entries on the EOI form, 655 were immediately excluded. Of the excluded entries, 41 did not have an Australian mobile number. These 41 entries were among the first 100 EOIs and were believed to be bots. After adding a reCAPTCHA to the REDCap screening survey, no further suspicious entries were received. Of the remaining, 462 entries were incomplete, 145 were duplicate entries, and 32 withdrew their EOI postscreening. In addition, 328 entries were ineligible, as they did not meet the inclusion criteria, with reasons for exclusion shown in Figure 1.

A total of 481 potential participants scored above the cut point on the IOI-S. A total of 292 participants were unable to be contacted to complete the EDE-Q (per protocol for further screening for eating disorder risk). A further 189 potential participants were referred to the InsideOut Institute for assessment from eating disorder expert clinicians. Of those, 104 were unable to be contacted by the eating disorder expert clinicians (and were therefore marked as ineligible), 38 were ineligible postcall as they were assessed as high risk. A further 25 potential participants withdrew at this step, and 22 potential participants were assessed as eligible by the psychologist and sent the e-consent form.

A total of 927 potential participants were eligible and sent the e-consent form. Of those, 506 were unable to be contacted and the e-consent form was never signed. The e-consent form was signed by 421 participants, and they were sent the baseline surveys, but 31 participants did not commence answering baseline questions, giving 390/2369 (16.4%) as participants enrolled in this study.

Figure 1. Progression of participants from screening to enrollment. AUS: Australian; ED: eating disorder.



Factors Associated With Nonparticipation

During screening, 537 potential participants were identified as eligible but did not proceed to enrollment, and 390 participants enrolled in the Health4Me Study. Chi-square tests indicated that there were statistically significant differences in screening characteristics between eligible participants who did and did not enroll in this study for gender and recruitment method. Gender differences were significant (χ^2_{3927}=9.8, P=.02); ASRs indicated fewer males and more individuals reporting "other" enrolled than expected by chance alone. Additionally, the recruitment method was significant (χ^2_{3925}=17.39, P<.001), ASRs indicated fewer participants enrolled through Instagram and more enrolled through other methods (eg, known networks or word of mouth) than expected by chance alone. No differences were observed for other screening characteristics. A full breakdown of screening characteristics between those who were eligible and did or did not enroll is available in Table 3.

Table 3. Comparison of screening characteristics between those who were eligible who did and did not enroll in the Health4Me Study.

	Total eligible and not enrolled (n=537)	Total enrolled (n=390)	Chi-square (*df*)	*P* value
Age (years)			3.8 (1927)	.05
12-14	80	41		
15-18	457	349		
Gender			9.8 (3927)	.02[a]
Male	166	92		
Female	347	274		
Other	11	17		
Prefer not to say	13	7		
BMI[b]			2.1 (3878)	.55
Underweight	21	16		
Healthy weight	410	279		
Above a healthy weight	60	51		
Well above a healthy weight	21	20		
Attending high school			0.5 (1927)	.82
Yes	464	339		
No	73	51		
Recruitment strategy[c]			17.3 (3925)	<.001[a]
Facebook	18	22		
Instagram	470	301		
Other social media platform[d]	4	5		
Other[e]	44	61		

[a]Statistically significant.
[b]Due to being asked gender during screening and not sex assigned at birth, we are unable to accurately calculate BMI for those who listed their gender as "other" or "prefer not to say."
[c]One record missing from each for recruitment strategy. Total eligible and not enrolled (n=536), and total enrolled (n=389).
[d]Due to small numbers, categories of Twitter/X, TikTok, and other social media platform were combined.
[e]Due to small numbers, categories of headspace, general practitioner or doctor, and other were combined.

Discussion

Principal Results

The Health4Me Study aimed at improving physical activity and nutrition behaviors among those aged 12 to 18 years. A total of 2369 EOIs were received, and 390/2369 (16.4%) participants were recruited in less than 12 months. Social media was the main source of recruitment. The research team did try to engage with schools, known networks, and relevant youth organizations via emails with limited success. Social media advertisements through Meta were effective, reaching 408,077 unique accounts across all states and territories in Australia. Overall, social media advertisements were low cost (Aus $3.89 per participant enrolled [approximately US $2.58]). From screening to enrollment, there were multiple points of dropout. Of the EOIs from potential participants who were eligible (927/2369, 39.1%), statistically significant differences were observed for those who did and did not enroll in terms of gender and recruitment method. Fewer males and more individuals reporting their gender as "other" enrolled than expected by chance alone. In addition, fewer individuals enrolled through Instagram and more enrolled through other methods (eg, known networks or word of mouth) than expected by chance alone.

Comparison With Prior Work

Virtual clinical trials have the potential to address challenges in traditional site-based recruitment and be cost-effective [20]. Yet, prevention programs among adolescents are known to have the lowest recruitment rates [35], and stakeholders have identified that a prevention lens may not be engaging for adolescents [4]. In the Health4Me Study, a digital preventive intervention, digital recruitment strategies that were employed were effective, recruiting 390 adolescents in less than 12 months. The Health4Me Study was guided by factors associated with successful recruitment from a previous virtual clinical trial [36], including (1) national recruitment, (2) self-referrals, (3) unmet need for trial intervention, (4) patient and public involvement, (5) regular monitoring and communication, and (6) reimbursement and early exclusion. In the Health4Me Study, a national sample was recruited and participants self-referred into this study. In addition, there are limited prevention programs currently available for adolescents [37], and the intervention and all advertising materials were co-designed with adolescents [29]. A small day-to-day research team was employed who communicated regularly through detailed screening and recruitment logs, and participants were reimbursed through online gift vouchers after completing all study activities at baseline and 6-month follow-up.

The costs reported in this study for social media advertising are lower per enrolled participant than what has previously been reported in reviews (approximately US $3-US $628) [9,38], however these studies mostly report on Facebook and compare social media to traditional in-person recruitment. Limited research is available reporting virtual clinical trial recruitment costs to recruit adolescents. A virtual clinical trial, which aimed to prevent and reduce cyberbullying among adolescents that used Instagram for study recruitment, found a higher consent rate than the Health4Me Study (24.4% vs 16.4%) yet had much higher social media advertisement costs (approximately US $19 versus approximately US $2.59 per enrolled participant) [39]. It is essential for future virtual clinical trials to report costs associated with recruitment to understand their cost-effectiveness for enrolling participants from the target population.

Virtual clinical trials allow remote access to research, potentially enhancing the diversity of participants, and recruiting from hard-to-reach populations [20]. In the Health4Me Study, it was observed that more individuals reporting their gender as "other" enrolled than expected by chance alone. This "other" category captures any gender other than male or female (eg, nonbinary or transgender). In another virtual clinical trial targeting cyberbullying found that nearly half of the participants recruited via Instagram identified as lesbian, gay, or bisexual [39]. It was also observed that less eligible males enrolled in the Health4Me Study than expected by chance alone. When looking at the social media advertisements, they reached less males overall. Evidence from large datasets demonstrates that females spend more time overall and more time per day on social media [40,41]. Additionally, another virtual clinical trial among an older population found that males were underrepresented [42]. Future efforts should be directed to identifying effective methods to recruit males to virtual clinical trials.

Another factor considered to attract hard-to-reach participants online is that those interested can self-refer into this study. A previous study, which aimed to assess effectiveness of online behavioral therapy for tics among young people, found that the majority of participants self-referred from online [36], enabling those who were not under the care of mental health clinicians to be included. The Health4Me Study is unique in that participants who are aged 15 years and older can consent themselves into this study, without the need for parent or guardian consent. This was approved by the ethics committee, with support from our youth advisory group as the Health4Me Study is a low-risk, preventive health intervention. This capacity to self-refer gives adolescents some autonomy around their health, especially given that preventive care is seldom given within primary care to this age group [43].

Within this study, less eligible adolescents enrolled through Instagram than were expected by chance alone, and more enrolled through other methods (eg, known networks or word of mouth) than what was expected by chance alone. Hypothesized reasons for this are around trust in health information that adolescents view online, adolescents being discouraged from sharing personal information online, and having poor knowledge and attitudes on clinical trials [44]. Previous reviews show that adolescents often distrust health information found online yet continue to engage with this information [45]. In terms of health information on social media, friends and networks are particularly important for gaining adolescents trust in this space [46]. Future studies planning to recruit adolescents through social media could explore the use of peer referral or endorsement from youth advisors or reputable organizations (eg, study sponsor) to gain an increased level of trust. In addition, adolescents are acutely aware of how their personal data are being used, and building trust and authenticity among this population is vital [31]. Partnerships with known youth health organizations and endorsement of the clinical trial through their own social media accounts may be useful to increase trust among adolescents.

Within the Health4Me Study, there were multiple points of dropout from screening to enrollment. The largest point of dropout was those who were eligible and sent the consent form but never responded. For all eligible participants, the research team sent the consent form twice via email, however after no response they were marked "unable to contact." Though emails are a highly acceptable form of communication among adolescents [47], future efforts should be directed to streamlining processes of screening and consent for scalability of future trials. Previous studies have aimed to do this using mobile apps, for example, ResearchKit (Apple Inc) [48], which is an open-source software framework designed to streamline the process of screening and consenting participants into research studies. Evidence of success is available for research studies among adults [49,50], yet no outcomes are currently available among adolescents [51]. Other strategies for enhancing communication with adolescents could also be explored in the future (with appropriate ethical approval), such as text messaging and direct messaging on social media platforms.

The second highest rate of dropout among participants was those who required further screening for a potential eating disorder. Out of 2369 potential participants, 292 (12.3%) did not complete an EDE-Q and were therefore excluded, and 189 (8.0%) required clearance through a phone call with this study's psychologist. When compared to the prevalence of eating disorders overall among Australian adolescents, this rate is lower than what has previously been reported (point prevalence of 22.2%) [52]. Thus, screening for eating disorders was not identified as a barrier to enrollment, rather an important safety precaution for potential identification of disordered eating among this population in a preventive intervention.

Limitations

Limitations in this study exist. First, this study is not representative of all adolescents due to inclusion criteria, which remove some groups. However, as this is a prevention intervention, the inclusion criteria aim to represent a large percentage of the adolescent population within Australia. Second, there are restrictions on advertising to adolescents via social media and changes are constantly occurring in this

space. Though the inclusion criteria for age in this study was those aged 12 to 18 years, social media advertisements are unable to be targeted to adolescents aged younger than 13 years, as you can only establish a social media account if you are over 13 years. Advertisements were developed for distribution on Snapchat; however, advertising of clinical trials is not allowed on its platform. Therefore, recruitment of adolescents via social media is also a limitation to reaching adolescents aged <13 years. Third, adolescents report that they find recruitment via social media to be feasible and acceptable for recruitment and retention [53,54]. However, this was not assessed within this study as follow-ups are ongoing. Adolescent perceptions for using social media for recruitment will be assessed in the process evaluation for the Health4Me Study, by assessing retention rates and analyzing focus group data. The findings of this study require validation with studies among other adolescent populations and other types of interventions.

Conclusions

Within the Health4Me Study, it was observed that recruitment was most effective via social media, and this was low cost per participant enrolled. Throughout the screening to enrollment process, there were multiple points of dropout, and future efforts should be directed toward streamlining screening and enrollment processes for scalability of future trials. In addition, our results highlight the importance of building trust among clinical trials and health information generally among adolescents on social media for future success in recruiting adolescents via this digital strategy.

Acknowledgments

The team would like to acknowledge Jessie Zhou who assisted with participant screening and recruitment for the Health4Me Study. We would also like to acknowledge Dr Karen Spielman and Dr Kyra Sim from the Health4Me Steering Committee, and Teisha Schrimer from the Mid North Coast Local Health District, who were helpful in promoting this study among their known networks. We would also like to acknowledge Judith Fethney from the Susan Wakil School of Nursing and Midwifery for statistical support. The Health4Me Team is comprised of the following authors: Katharine Steinbeck, PhD—Specialty of Child and Adolescent Health, Westmead Clinical School, Faculty of Medicine and Health, The University of Sydney, Westmead, NSW, Australia; Gemma Figtree, PhD—Sydney Clinical School (Northern), Faculty of Medicine and Health, The University of Sydney, Sydney, NSW, Australia; Robyn Gallagher, PhD—Susan Wakil School of Nursing and Midwifery, Faculty of Medicine and Health, The University of Sydney, Sydney, NSW, Australia; Melissa Kang, PhD—General Practice Clinical School, Sydney Medical School, Faculty of Medicine and Health, The University of Sydney, Sydney, NSW, Australia; Karice Hyun, PhD—School of Health Sciences, Faculty of Medicine and Health, The University of Sydney, Sydney, NSW, Australia; Karen Spielman, MBBS (Hons)—InsideOut Institute, Faculty of Medicine and Health, University of Sydney, Sydney, NSW, Australia; Kyra A Sim, PhD—Metabolism & Obesity Service, Sydney Local Health District, Sydney, NSW, Australia; Tim Usherwood, MD—General Practice Clinical School, Sydney Medical School, Faculty of Medicine and Health, The University of Sydney, Sydney, NSW, Australia; Charlotte Hepse, MBBS (Hons)—The University of Notre Dame Australia, Sydney, NSW, Australia; Liliana Laranjo, PhD—Westmead Applied Research Centre, Faculty of Medicine and Health, The University of Sydney, Westmead, NSW, Australia; John Skinner, PhD—Djurali Centre for Aboriginal and Torres Strait Islander Health Research, Heart Research Institute, Sydney, NSW, Australia; Danielle Castles—Nepean Blue Mountains Local Health District, Penrith, NSW, Australia; Katrina E Champion, PhD—The Matilda Centre for Research in Mental Health and Substance Use, The University of Sydney, Sydney, NSW, Australia; Lauren A Gardner, PhD—The Matilda Centre for Research in Mental Health and Substance Use, The University of Sydney, Sydney, NSW, Australia. The Health4Me Study is funded by the Australian Government Department of Health Medical Research Future Fund Primary Care Grant (2006315). The funder has no role in this study's design; collection, analysis, and interpretation of data; or writing of this paper. RR is funded by a SOLVE-CHD Completion Scholarship. ART is funded by a University of Sydney Postgraduate Research Scholarship in Adolescent Health and Nutrition. JR is supported by an NHMRC Investigator Grant (Leadership Level 2 [GNT1143538]). SRP is supported by a National Heart Foundation Future Leader Fellowship (106646) and University of Sydney Horizon Fellowship.

Data Availability

The datasets generated or analyzed during this study are not publicly available due to ethical approvals that protect the data of participants who have taken part in the study.

Authors' Contributions

RR, S Maguire, KW, S Mihrshahi, MLH, JR, SRP, and The Health4Me Team conceptualized the study. RR, ART, S Barakat, SR and S Boulet conducted the investigation. RR conducted the formal analysis and wrote the initial draft. JR and SRP provided supervision. All authors reviewed and edited this paper. All authors approved the final version of this paper.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Health4Me social media advertisement examples.

[DOCX File (Microsoft Word File), 1461 KB-Multimedia Appendix 1]

References

1. Patton GC, Sawyer SM, Santelli JS, et al. Our future: a Lancet commission on adolescent health and wellbeing. The Lancet. Jun 2016;387(10036):2423-2478. [doi: 10.1016/S0140-6736(16)00579-1]
2. Australian Institute of Health and Welfare. Health System Spending per Case of Disease and for Certain Risk Factors. AIHW; 2022.
3. Sanci L, Steinbeck K, Jan S, et al. Access 3: young people and the health system in the digital age-final research report. Department of General Practice Westmead, The University of Sydney and the Australian Centre for Public and Population Health Research, The University of Technology Sydney, Australia; 2018.
4. Raeside R, Todd A, Sim KA, et al. Accelerating implementation of adolescent digital health prevention programs: analysis of insights from Australian stakeholders. Front Public Health. 2024;12:1389739. [doi: 10.3389/fpubh.2024.1389739] [Medline: 38765492]
5. Mathews B. Adolescent capacity to consent to participate in research: a review and analysis informed by law, human rights, ethics, and developmental science. Laws. 2023;12(1):2. [doi: 10.3390/laws12010002]
6. Dalessandro C. Recruitment tools for reaching millennials: the digital difference. Int J Qual Methods. 2018;17(1):1609406918774446. [doi: 10.1177/1609406918774446]
7. Khoury MJ, Iademarco MF, Riley WT. Precision public health for the era of precision medicine. Am J Prev Med. Mar 2016;50(3):398-401. [doi: 10.1016/j.amepre.2015.08.031] [Medline: 26547538]
8. Brøgger-Mikkelsen M, Ali Z, Zibert JR, Andersen AD, Thomsen SF. Online patient recruitment in clinical trials: systematic review and meta-analysis. J Med Internet Res. Nov 4, 2020;22(11):e22179. [doi: 10.2196/22179] [Medline: 33146627]
9. Darmawan I, Bakker C, Brockman TA, Patten CA, Eder M. The role of social media in enhancing clinical trial recruitment: scoping review. J Med Internet Res. Oct 26, 2020;22(10):e22810. [doi: 10.2196/22810] [Medline: 33104015]
10. Rait MA, Prochaska JJ, Rubinstein ML. Recruitment of adolescents for a smoking study: use of traditional strategies and social media. Transl Behav Med. Sep 2015;5(3):254-259. [doi: 10.1007/s13142-015-0312-5] [Medline: 26327930]
11. Moreno MA, Waite A, Pumper M, Colburn T, Holm M, Mendoza J. Recruiting adolescent research participants: in-person compared to social media approaches. Cyberpsychol Behav Soc Netw. Jan 2017;20(1):64-67. [doi: 10.1089/cyber.2016.0319] [Medline: 27976951]
12. Parker JN, Hunter AS, Bauermeister JA, Bonar EE, Carrico A, Stephenson R. Comparing social media and in-person recruitment: lessons learned from recruiting substance-using, sexual and gender minority adolescents and young adults for a randomized control trial. JMIR Public Health Surveill. Dec 1, 2021;7(12):e31657. [doi: 10.2196/31657] [Medline: 34855613]
13. Ellington M, Connelly J, Clayton P, et al. Use of Facebook, Instagram, and Twitter for recruiting healthy participants in nutrition-, physical activity-, or obesity-related studies: a systematic review. Am J Clin Nutr. Feb 9, 2022;115(2):514-533. [doi: 10.1093/ajcn/nqab352] [Medline: 34669955]
14. Frampton GK, Shepherd J, Pickett K, Griffiths G, Wyatt JC. Digital tools for the recruitment and retention of participants in randomised controlled trials: a systematic map. Trials. Jun 5, 2020;21(1):478. [doi: 10.1186/s13063-020-04358-3] [Medline: 32498690]
15. Watson SE, Smith P, Snowden J, et al. Facilitators and barriers to pediatric clinical trial recruitment and retention in rural and community settings: a scoping review of the literature. Clin Transl Sci. Apr 2022;15(4):838-853. [doi: 10.1111/cts.13220] [Medline: 35037409]
16. Amon KL, Campbell AJ, Hawke C, Steinbeck K. Facebook as a recruitment tool for adolescent health research: a systematic review. Acad Pediatr. 2014;14(5):439-447. [doi: 10.1016/j.acap.2014.05.049] [Medline: 25169155]
17. Ford KL, Albritton T, Dunn TA, Crawford K, Neuwirth J, Bull S. Youth study recruitment using paid advertising on Instagram, Snapchat, and Facebook: cross-sectional survey study. JMIR Public Health Surveill. Oct 9, 2019;5(4):e14080. [doi: 10.2196/14080] [Medline: 31599739]
18. McDermott MM, Newman AB. Remote research and clinical trial integrity during and after the coronavirus pandemic. JAMA. May 18, 2021;325(19):1935-1936. [doi: 10.1001/jama.2021.4609] [Medline: 33885728]
19. Petrini C, Mannelli C, Riva L, Gainotti S, Gussoni G. Decentralized clinical trials (DCTs): a few ethical considerations. Front Public Health. 2022;10:1081150. [doi: 10.3389/fpubh.2022.1081150] [Medline: 36590004]
20. Ng CE, Bowman S, Ling J, Bagshaw R, Birt A, Yiannakou Y. The future of clinical trials-is it virtual? Br Med Bull. Dec 11, 2023;148(1):42-57. [doi: 10.1093/bmb/ldad022] [Medline: 37681298]
21. National Academies of Sciences, Engineering, and Medicine. Virtual Clinical Trials: Challenges and Opportunities: Proceedings of a Workshop. National Academies Press (US); 2019. [doi: 10.17226/25502]

22. Wong CA, Madanay F, Ozer EM, et al. Digital health technology to enhance adolescent and young adult clinical preventive services: affordances and challenges. J Adolesc Health. Aug 2020;67(2S):S24-S33. [doi: 10.1016/j.jadohealth.2019.10.018] [Medline: 32718511]
23. Van Eck K, Thakkar M, Matson PA, Hao L, Marcell AV. Adolescents' patterns of well-care use over time: who stays connected. Am J Prev Med. May 2021;60(5):e221-e229. [doi: 10.1016/j.amepre.2020.12.008] [Medline: 33648787]
24. Brisson J, Ravitsky V, Williams-Jones B. "Fostering autonomy" for adolescents to access health services: a need for clarifications. J Adolesc Health. Jun 2021;68(6):1038-1039. [doi: 10.1016/j.jadohealth.2021.03.007] [Medline: 34023061]
25. Raeside R, Spielman K, Maguire S, et al. A healthy lifestyle text message intervention for adolescents: protocol for the Health4Me randomized controlled trial. BMC Public Health. Sep 23, 2022;22(1):1805. [doi: 10.1186/s12889-022-14183-9] [Medline: 36138375]
26. Bryant E, Miskovic-Wheatley J, Touyz SW, Crosby RD, Koreshe E, Maguire S. Identification of high risk and early stage eating disorders: first validation of a digital screening tool. J Eat Disord. Sep 6, 2021;9(1):109. [doi: 10.1186/s40337-021-00464-y] [Medline: 34488899]
27. Forsén Mantilla E, Birgegård A, Clinton D. Factor analysis of the adolescent version of the Eating Disorders Examination Questionnaire (EDE-Q): results from Swedish general population and clinical samples. J Eat Disord. 2017;5(1):19. [doi: 10.1186/s40337-017-0140-8] [Medline: 28580141]
28. Afkinich JL, Blachman-Demner DR. Providing incentives to youth participants in research: a literature review. J Empir Res Hum Res Ethics. Jul 2020;15(3):202-215. [doi: 10.1177/1556264619892707] [Medline: 31829071]
29. Raeside R, Todd A, Wardak S, et al. Striking the right balance: co-designing the Health4Me healthy lifestyle digital health intervention with adolescents. Res Involv Engagem. Dec 7, 2023;9(1):114. [doi: 10.1186/s40900-023-00524-4] [Medline: 38062532]
30. Meta. About advertising to teens. Meta. 2024. URL: https://www.facebook.com/business/help/229435355723442 [Accessed 2024-11-16]
31. Raeside R, Jia SS, Redfern J, Partridge SR. Navigating the online world of lifestyle health information: qualitative study with adolescents. JMIR Pediatr Parent. Feb 11, 2022;5(1):e35165. [doi: 10.2196/35165] [Medline: 35147506]
32. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)--a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. Apr 2009;42(2):377-381. [doi: 10.1016/j.jbi.2008.08.010] [Medline: 18929686]
33. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. May 6, 2000;320(7244):1240-1243. [doi: 10.1136/bmj.320.7244.1240] [Medline: 10797032]
34. Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. Pediatr Obes. Aug 2012;7(4):284-294. [doi: 10.1111/j.2047-6310.2012.00064.x] [Medline: 22715120]
35. Kilicel D, De Crescenzo F, Pontrelli G, Armando M. Participant recruitment issues in child and adolescent psychiatry clinical trials with a focus on prevention programs: a meta-analytic review of the literature. J Clin Med. Mar 16, 2023;12(6):2307. [doi: 10.3390/jcm12062307] [Medline: 36983307]
36. Hall CL, Sanderson C, Brown BJ, et al. Opportunities and challenges of delivering digital clinical trials: lessons learned from a randomised controlled trial of an online behavioural intervention for children and young people. Trials. Dec 9, 2020;21(1):1011. [doi: 10.1186/s13063-020-04902-1] [Medline: 33298127]
37. Partridge SR, Reece L, Sim KA, et al. An analysis of current obesity strategies for adolescents in NSW against best practice recommendations: Implications for researchers, policymakers and practitioners. Health Prom J Aust. Apr 2023;34(2):390-397. [doi: 10.1002/hpja.606]
38. Topolovec-Vranic J, Natarajan K. The use of social media in recruitment for medical research studies: a scoping review. J Med Internet Res. Nov 7, 2016;18(11):e286. [doi: 10.2196/jmir.5698] [Medline: 27821383]
39. Kutok ER, Doria N, Dunsiger S, et al. Feasibility and cost of using Instagram to recruit adolescents to a remote intervention. J Adolesc Health. Nov 2021;69(5):838-846. [doi: 10.1016/j.jadohealth.2021.04.021] [Medline: 34059428]
40. Twenge JM, Martin GN. Gender differences in associations between digital media use and psychological well-being: evidence from three large datasets. J Adolesc. Feb 2020;79:91-102. [doi: 10.1016/j.adolescence.2019.12.018] [Medline: 31926450]
41. Social media usage by gender 2024. OBERLO. 2024. URL: https://www.oberlo.com/statistics/social-media-usage-by-gender [Accessed 2024-09-23]
42. Fortunato MP, Girard A, Coratti S, et al. Investigating racial and gender disparities in virtual randomized clinical trial enrollment: Insights from the BE ACTIVE study. Am Heart J. Oct 2024;276:120-124. [doi: 10.1016/j.ahj.2024.06.003] [Medline: 39182941]

43. Irwin CE Jr, Adams SH, Park MJ, Newacheck PW. Preventive care for adolescents: few get visits and fewer get services. Pediatrics. Apr 2009;123(4):e565-72. [doi: 10.1542/peds.2008-2601] [Medline: 19336348]
44. Brown DL, Cowdery JE, Jones TS, Langford A, Gammage C, Jacobs TL. Adolescent knowledge and attitudes related to clinical trials. Clin Trials. Jun 2015;12(3):212-214. [doi: 10.1177/1740774515571443] [Medline: 25673637]
45. Freeman JL, Caldwell PHY, Scott KM. The role of trust when adolescents search for and appraise online health information. J Pediatr. Jun 2020;221:215-223. [doi: 10.1016/j.jpeds.2020.02.074] [Medline: 32446485]
46. Freeman JL, Caldwell PHY, Scott KM. How adolescents trust health information on social media: a systematic review. Acad Pediatr. 2023;23(4):703-719. [doi: 10.1016/j.acap.2022.12.011] [Medline: 36581098]
47. Borus J, Weas S, Fleegler E, Kahn J, Chan E. Email isn't just for old people: teen acceptability of internet communication with medical providers. Clin Pediatr (Phila). Dec 2016;55(14):1350-1353. [doi: 10.1177/0009922815619369] [Medline: 26637403]
48. ResearchKit and CareKit. Apple. 2016. URL: https://www.apple.com/au/researchkit/ [Accessed 2024-11-16]
49. Bot BM, Suver C, Neto EC, et al. The mPower study, Parkinson disease mobile data collected using ResearchKit. Sci Data. Mar 3, 2016;3:160011. [doi: 10.1038/sdata.2016.11] [Medline: 26938265]
50. Chan YFY, Wang P, Rogers L, et al. The Asthma Mobile Health Study, a large-scale clinical observational study using ResearchKit. Nat Biotechnol. Apr 2017;35(4):354-362. [doi: 10.1038/nbt.3826] [Medline: 28288104]
51. Lalloo C, Pham Q, Cafazzo J, Stephenson E, Stinson J. A ResearchKit app to deliver paediatric electronic consent: protocol of an observational study in adolescents with arthritis. Contemp Clin Trials Commun. Mar 2020;17:100525. [doi: 10.1016/j.conctc.2020.100525] [Medline: 32211557]
52. Mitchison D, Mond J, Bussey K, et al. DSM-5 full syndrome, other specified, and unspecified eating disorders in Australian adolescents: prevalence and clinical significance. Psychol Med. Apr 2020;50(6):981-990. [doi: 10.1017/S0033291719000898] [Medline: 31043181]
53. Anderson E, Parslow R, Hollingworth W, et al. Recruiting adolescents with chronic fatigue syndrome/myalgic encephalomyelitis to internet-delivered therapy: internal pilot within a randomized controlled trial. J Med Internet Res. Aug 12, 2020;22(8):e17768. [doi: 10.2196/17768] [Medline: 32784188]
54. Wisk LE, Nelson EB, Magane KM, Weitzman ER. Clinical trial recruitment and retention of college students with type 1 diabetes via social media: an implementation case study. J Diabetes Sci Technol. May 2019;13(3):445-456. [doi: 10.1177/1932296819839503] [Medline: 31010315]

Abbreviations

ANZCTR: Australia New Zealand Clinical Trials Registry
ASR: adjusted standardized residual
EDE-Q: Eating Disorder Examination Questionnaire
EOI: Expression of Interest
IOI-S: InsideOut Institute Screener
NSW: New South Wales
REDCap: Research Electronic Data Capture

Edited by Sherif Badawy; peer-reviewed by Digby Krastins, Timothy Johnson; submitted 04.06.2024; final revised version received 24.09.2024; accepted 11.10.2024; published 16.12.2024

Please cite as:
Raeside R, Todd AR, Barakat S, Rom S, Boulet S, Maguire S, Williams K, Mihrshahi S, Hackett ML, Redfern J, Partridge SR, The Health4Me Team
Recruitment of Adolescents to Virtual Clinical Trials: Recruitment Results From the Health4Me Randomized Controlled Trial
JMIR Pediatr Parent 2024;7:e62919
URL: https://pediatrics.jmir.org/2024/1/e62919
doi: 10.2196/62919

Appendix 1: Health4Me Social Media Advertisement Examples

Chapter One

Introduction

Chapter Two

Systematic Review with Meta-Analysis

Chapter Three

Qualitative Study with Adolescents

HEALTH4ME

Chapter Four

Co-Design of Health4Me

Chapter Five

Health4Me RCT Protocol

Chapter Six

Health4Me Recruitment

Chapter Seven

Qualitative Study with Stakeholders

Chapter Eight

Discussion and Conclusions

CHAPTER SEVEN: Accelerating implementation of adolescent digital health prevention programs: analysis of insights from Australian stakeholders

Preface to the Chapter

Chapter Six provided evidence that digital recruitment strategies were low-cost with the potential to increase trial participation, with social media being the most effective. This chapter (Chapter Seven) presents the published manuscript of a qualitative study titled 'Accelerating implementation of adolescent digital health prevention programs: analysis of insights from Australian stakeholders', thereby addressing Aim 7 of this thesis. Ethics approvals and participant information and consent forms for this study are presented in Appendix E. This qualitative study has been peer reviewed (submitted 22nd February 2024, resubmitted with corrections following reviewer comments 8th April 2024), accepted 10th April 2024) and published (3rd May 2024) in *Frontiers in Public Health.* Authors contributions to this paper are outlined in the authorship attribution statement. Chapter Seven was disseminated in the following ways:

Published peer reviewed manuscript

Raeside R, Todd A, Sim KA, Kang M, Mihrshahi S, Gardner LA, Champion KE, Skinner J, Laranjo L, Steinbeck K, Redfern J and Partridge SR. Accelerating implementation of adolescent digital health prevention programs: analysis of insights from Australian stakeholders. *Front. Public Health* 2024; 12:1389739. doi: 10.3389/fpubh.2024.1389739

Conference presentations

1. **Raeside R** (24-25/07/2024) Accelerating implementation of adolescent digital health prevention programs in Australia. 12-min oral. Faculty of Medicine and Health HDR Conference 2024. Sydney, Australia
2. **Raeside R** et al (8-10/11/2023) Exploring barriers and enablers to implementation of digital health prevention programs for adolescents. 10-min oral. Australian Association for Adolescent Health Youth Health Conference 2023. Adelaide, Australia.

Author attribution statement

This statement is to stipulate the contribution of Rebecca Raeside in the preparation and submission of the following manuscript: ‘Accelerating implementation of adolescent digital health prevention programs: analysis of insights from Australian stakeholders‘. The convention is that the author with the principal contribution to the study is the first author.

Rebecca Raeside, during her PhD candidature, developed the concept for the study, designed the data collection instruments, conducted the interviews, analysed the data, interpreting the results, drafting the manuscript and subsequent revisions and coordinating submission for publication.

The individual roles of co-authors are listed below:

TASK	ROLE OF CO-AUTHORS
CONCEPTUALISATION	RR
REFINING THE RESEARCH QUESTION	ALL
DESIGNING DATA COLLECTION INSTRUMENTS	RR, AT, SRP
CONDUCTING THE INTERVIEWS	RR, AT
TRANSCRIPTION OF INTERVIEWS	RR
ANALYSIS AND INTERPRETATION OF INTERVIEWS	RR, AT, SRP
DRAFTING MANUSCRIPT	RR
REVISION AND CRITICAL COMMENTS ON MANUSCRIPT	ALL

Rebecca Raeside 26 Sept 2024

As supervisor for the candidature upon which this thesis is based, I can confirm that the author attribution statement above is correct.

Dr Stephanie Partridge 26 Sept 2024

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 03 May 2024
DOI 10.3389/fpubh.2024.1389739

OPEN ACCESS

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RECEIVED 22 February 2024
ACCEPTED 10 April 2024
PUBLISHED 03 May 2024

CITATION
Raeside R, Todd A, Sim KA, Kang M, Mihrshahi S, Gardner LA, Champion KE, Skinner J, Laranjo L, Steinbeck K, Redfern J and Partridge SR (2024) Accelerating implementation of adolescent digital health prevention programs: analysis of insights from Australian stakeholders. *Front. Public Health* 12:1389739. doi: 10.3389/fpubh.2024.1389739

Accelerating implementation of adolescent digital health prevention programs: analysis of insights from Australian stakeholders

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Background: Chronic disease risk factors are increasing amongst adolescents, globally. Digital health prevention programs, which provide education and information to reduce chronic disease risk factors need to be equitable and accessible for all. For their success, multiple highly engaged stakeholders should be involved in development and implementation. This study aimed to evaluate stakeholders' support for, and perspectives on potential public health impact of digital health prevention programs for adolescents and potential pathways for future implementation.

Methods: Qualitative semi-structured online interviews with stakeholders. Stakeholder mapping identified key individuals, groups and organizations across Australia that may influence the implementation of digital health prevention programs for adolescents. Recorded and transcribed interviews were analyzed within the Reach, Effectiveness, Adoption, Implementation and Maintenance (RE-AIM) Framework, using deductive content analysis.

Findings: Nineteen interviews were conducted in 2023 with stakeholders from government, health, non-government organizations, youth services, education, community settings and others. Four overarching themes were identified: (i) existing digital health initiatives are not fit for purpose; (ii) the co-creation of digital health prevention programs is critical for successful implementation; (iii) digital health prevention programs must address equity and the unique challenges raised by technology and; (iv) system level factors must be addressed.

Interpretation: Stakeholders broadly supported digital health prevention programs, yet raised unique insights to ensure that future programs create public health impact by improving chronic disease risk factors among adolescents.

These insights can be applied in future development of digital health prevention programs for adolescents to strengthen widespread implementation.

KEYWORDS

implementation science, digital health, adolescents, prevention, qualitative study, public health

Introduction

Globally, adolescents 10–24 years face multiple challenges which often hinder them to live fulfilling and productive lives as adults (1). Among adolescents 11–17 years, there has been a three-fold increase in the prevalence of four or more chronic disease risk factors, such as physical inactivity and insufficient fruit and vegetable consumption (2). As such, adolescents often enter young adulthood at a higher risk of chronic diseases than when they entered adolescence (3). The roll-out of preventive health strategies that are equitable for all is one of the many priority areas for action that the Australian Government has set to improve chronic disease risk factors among adolescents (4), and this has been mirrored in global frameworks (5). To serve all adolescents who are seeking support, health care systems will require services that can overcome existing barriers that adolescents face in accessing health care services (6, 7).

The use of digital health programs to provide adolescents with education and information to reduce chronic disease risk factors is promising (8, 9). The Australian National Preventive Health Strategy has outlined that governments and health care systems should embrace the digital revolution to deliver preventive health care (10). Digital health programs are recommended to support adolescents to prevent obesity (11) and mental health prevention and treatment (12). However, programs that target mental health often do not focus on risk factors including nutrition and physical activity (13), and programs with an obesity prevention lens can be stigmatizing (14). Consultation with adolescent consumers have highlighted their desire for a holistic and integrated approach to support their health (15). Multiple stakeholders should come together to develop and implement digital health prevention programs that are both effective and in-line with adolescents needs, priorities, views, and values.

Typically, implementation research occurs after research has demonstrated effectiveness. Yet, when it comes to adolescent digital health programs, this phase-based model is potentially delaying their implementation into health care systems and community services (16). This can be for a multitude of reasons, including limited capacity and support from stakeholders, technology innovations or increased adolescent expectations for the programs (16). Engaging stakeholders meaningfully in the research process is recognized as an important strategy to translate research into public health policy and practice (17). Therefore, to implement digital health prevention programs into health care systems and community services, research is needed to map the stakeholders involved, understand their support for these programs and engage them early in the research process. The aim of this study was to evaluate stakeholders' support for, and perspectives on potential public health impact of digital health prevention programs for adolescents and potential pathways for future implementation.

Methods

Study design

Qualitative study using semi-structured interviews to evaluate stakeholders' perspectives. The study adhered to the consolidated criteria for reporting qualitative research (COREQ) guidelines (Appendix 1). Ethics approval was obtained from The University of Sydney Human Research Ethics Committee (approval number 2022/778), and all participants provided informed e-consent prior to participation.

Participants

Participants were stakeholders identified through a stakeholder mapping process led by three members of the research team (RR, AT, SRP), which identified key individuals, groups and organizations across Australia that may influence the success of implementation of digital health prevention programs for adolescents. Following the WHO Health Service Planning and Policy-Making Toolkit (18), RR, AT, and SRP conducted a brainstorming session to identify key individuals, groups, and organizations to interview based on their experience and networks within the fields of adolescent health, digital health, and public health. For groups and organizations, websites were searched to identify the key individual(s) to invite for an interview. If unable to deduce from the website, an email was sent to the generic inbox. Stakeholders were identified across sectors including government, heath, education, industry, non-government organizations (NGOs), youth services and community groups. Stakeholders were eligible to take part if they: (i) were aged 18 years or over; (ii) had an interest in supporting adolescent populations in their sector; (iii) were willing to provide insights from their involvement in adolescent-specific digital health prevention programs; and (iv) provided informed e-consent. Once stakeholders were identified, the research team reviewed the list excluded any individuals, groups or organizations which were duplicates.

Recruitment

Participants were invited via email to take part in an individual interview. Email invitations were sent with a link to the participant information sheet. All participants read the information sheet online, provided informed e-consent and were directed to an online survey to complete demographic characteristics (age, gender, ethnic background, sector, and location). Participants were contacted via email to organize a suitable date and time for the interview and were emailed the secure teleconference link.

10.3389/fpubh.2024.1389739

Data collection

The semi-structured interview guide was developed by the research team to address the research aims. Due to the varying nature of stakeholders, two interview guides were developed. One was developed for health and education organizations and the second for youth advocacy groups. Interviews started by the interviewer introducing the project. 'Digital health prevention programs' were defined as using range of technologies to protect, promote and sustain the populations health. 'Prevention' was defined as decreasing the risk, chance or likelihood of an individual developing chronic disease (e.g., obesity) or mental illness. Next, the interviewer asked participants broadly about digital health, their thoughts on important health prevention messages for adolescents and knowledge of any current digital or in-person health prevention programs. Following this, interview questions were structured within the RE-AIM Framework with specific questions about reach, effectiveness, adoption, implementation, and maintenance of digital health prevention programs. The RE-AIM Framework was developed to guide the planning and evaluation of programs that may assist the adoption and implementation of these into a range of settings (including health care and community settings) (19, 20).

All interviews were conducted online using Zoom videoconferencing (Zoom Video Communications Inc., San Jose, CA) from February to August 2023. Interviews were conducted by one of two female postgraduate researchers (RR and AT). Both RR and AT had previous experience in conducting interviews. The first stakeholder interview was reviewed by both interviewers to check for consistency between interview styles, no major changes were required. All participants were reminded of their ability to withdraw and that any question could be skipped if they were unsure or unwilling to answer. Interview recordings were a maximum of 45 min. Videoconference software provided separate audio and video recordings of the interviews. Video recordings were deleted, and audio recordings were retained for transcription. Transcripts were not returned to participants for comment. The semi-structured interview guide is provided in Appendix 2.

Analysis

Participant characteristics are summarized including age, gender, ethnic background, sector of work and location of current organization. A deductive content analysis was used to analyze the interview transcripts within the RE-AIM Framework for implementation (19–21). All qualitative analysis was conducted in NVivo (NVivo 1.7). One researcher (RR) set up the coding framework with five domains: reach, effectiveness, adoption, implementation, and maintenance. All 19 transcripts were coded to the coding framework, each transcript was coded at least twice by the research team (RR, AT, SRP). Next, each category of the framework was examined by RR, AT, and SRP to identify patterns in the data and new insights were formed. Through discussions, a consensus on the underlying themes within the framework was agreed upon and those results are presented. All quotes included in the findings are from the 19 interviews.

Results

The research team identified 60 unique stakeholders across different sectors. After reviewing the list of stakeholders for duplicates, nine were identified and removed. Therefore, 51 unique stakeholders were invited to participate in an interview. Of the 51 stakeholders invited, 19 participants were eligible and willing to take part in an interview and signed e-consent. After e-consent was signed, interviews were scheduled.

Participant characteristics

Participant characteristics are reported in Table 1. Participants were a range of ages, with at least one in each age category (range: 18–69). They were predominantly identified as female (14/19, 74%), Caucasian (11/19, 58%) and their organization was based in New South Wales (14/19, 74%). Participants came from sectors including government ($n=3$), health ($n=2$), non-government organizations ($n=4$), education ($n=3$), youth service ($n=2$), community ($n=2$) or other ($n=3$) including two adolescent health researchers and one educational designer. There was no difference in the perspectives given from different sectors, all quotes are accompanied by the sector which the participant was from. A summary of the identified themes and how they fit within the RE-AIM Framework can be seen in Figure 1, supporting quotes can be seen in Table 2.

Themes

Existing digital health initiatives are not fit for purpose

When asked about knowledge and reach of current digital health prevention programs for adolescents, many participants could not recall current examples of existing programs unless their role was situated in a school setting. Other programs which were commonly identified were mental health programs (e.g., headspace, Beyond Blue) yet they were unsure of the level of preventive health information within them.

> *'I know of pilots of things, but not nothing that's sort of been picked up and run. And I'm sure there are ones. In fact, I'm absolutely sure there are ones in the sort of mental health space, but I'm not so much. I'm not really an expert on those. So I do not, I'm not so aware of that.'* – ID 2 (Health)

> *'I'm not aware of any sort of public health type initiatives other than what's delivered in schools. So like I know about the school programs, they obviously look at health and nutrition and physical activity and mental health as part of the school curriculum. In primary school and in high school, but I'm not aware of any sort of broader public health programs.'* – ID 6 (Other)

When asked about the potential of future programs, participants showed broad support for the development and implementation of digital health prevention programs. They also

TABLE 1 Participant characteristics ($n = 19$).

Age (years)	18–29	4
	30–39	4
	40–49	5
	50–59	4
	60–69	2
Gender	Male	4
	Female	14
	Non-binary/gender diverse	1
Ethnic background	Caucasian	11
	New Zealander or Maori	1
	Chinese	1
	Middle Eastern	1
	Other	4
	Prefer not to say	1
Sector	Government	3
	Health	2
	Non-Government Organization	4
	Education	3
	Youth Service	2
	Community	2
	Other	3
Location of organization	NSW	14
	VIC	4
	ACT	1

ACT, Australian Capital Territory; NSW, New South Wales; VIC, Victoria.

suggested that they should be complementary to existing face-to-face initiatives.

> *'I think there's the potential to reach a lot of adolescents because we know that they are all online. Almost all of them are online and using social media. And so I think there is the potential to do it.'* – ID 6 (Other)

> *'Yeah, yeah, definitely could be complimentary. A lot of it, though, depends, I suppose on uptake and the willingness of young person to act to actually engage.'* – ID 15 (Education)

However, digital health prevention programs were not considered as a stand-alone setting. All stakeholders considered that programs would sit within existing initiatives, including school curriculum or complementary programs. However, these are constrained by limited resources and existing structures which have been shown to be ineffective. Specific contextual factors that were raised within this were the appropriate use of devices within a school setting and raising awareness of programs with staff.

> *'I do not see the digital health and sort of taking over it simply that it's going to be people are made aware of it. And so therefore, kids can be, you know, sort of directed to it as an extra source of help and support'* – ID 15 (Education)

> *'So for some people, digital health services can be the right level of support to address their problem, or the right mode. And that's it. But for others, it'll be sort of an adjunctive to support to other sort of perhaps clinical in person service delivery, that they are accessing as well. So it really like the sort of market is sort of almost endless, really, because there are so few young people who are not digitally engaged.'* – ID 11 (Youth Service)

> *'I think, what we one of the things, though, that we hear from young people is that younger people still relational. So there's, all of those things are good, and they like having them as an option. But I do not want them to replace face to face connection with, you know, workers or doctors or health professionals or, you know, whoever, you know, whoever would otherwise have run a program before it became an online thing.'* – ID 7 (NGO)

Another consideration raised was that a chronic disease prevention lens is not engaging for young people as it is not necessarily useful to them, and future programs will need to go through a different lens, e.g., holistic view of health and wellbeing.

> *'I mean, the difficulty of prevention is that for people to uptake, the intervention I guess it necessitates that they have a sense of usefulness for them. Like why would they so being proactive about their health? And I'm not sure all young people are really conscious or aware of that.'* – ID 3 (Other)

> *'So I think for them, it's more wellbeing is a really holistic concept … it's about how you feel mentally, it's about the environment that you live in. It's about whether you, you know, how you feel within yourself … I think for young people, it's much more holistic than it is for adults, whereas adults, it might be about, here's how you prevent diabetes, and here's how you prevent heart disease. And here's how you prevent, I do not think young people think in those terms, I think much more broadly about just how I feel about myself.'* – ID 7 (NGO)

Finally, it was recognized that it would be important to choose the right contact points to introduce a future digital health prevention program to adolescents. It was suggested that multiple entry points would be needed to engage adolescents. The two entry points which were identified and supported most were through schools and social media.

> *'I think there's no one way to reach out to young people and to help them engage, they have different styles, different types of things they like'* – ID 3 (Other)

> *'Um, it really depends on what I mean, if you are talking about physical activity, healthy eating, I would say probably best through schools'* – ID 5 (Health).

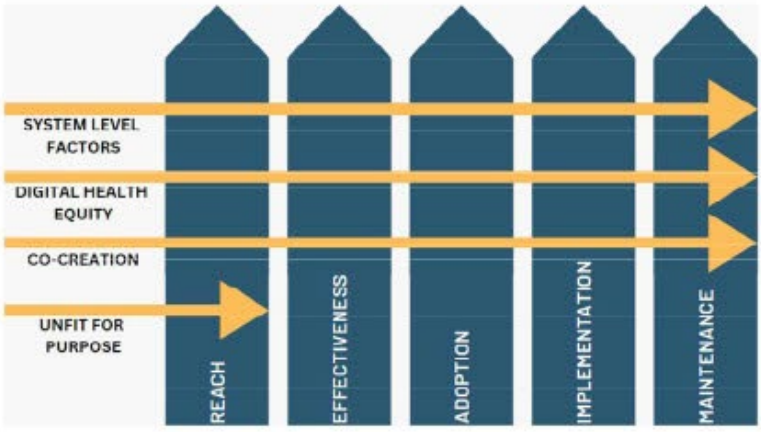

FIGURE 1
Representation of identified themes within the RE-AIM Framework for implementation.

> *'or it could be like social media. And perhaps, to get over that sort of hurdle of signing up, it might be good to engage some sort of influencers of potentially to talk about and encourage signing up.'* – ID 11 (Youth Service)

Since current initiatives are not fit for purpose, this theme did not extend beyond the exploration of reach within the RE-AIM Framework. There were three further themes which were identified by participants to be critical for the successful implementation of future digital health prevention programs for adolescents, which were identified within all five categories of the RE-AIM Framework and will be expanded below.

Co-creation of programs with adolescents is critical for success

Firstly, participants identified that future digital health prevention programs need to be co-created with a diverse group of young people for them to be supported by their organizations. They also had specific considerations including that programs were evidence-based, relevant to adolescents and target them directly.

> *'I think if it's, if it's sort of, if it's based on evidence, like evidence-based action is really key to us and youth informed, you know, youth, genuine youth engagement and co-design. If those two things are in place, then it's certainly something we'd support.'* – ID 8 (NGO)

> *'And, you know, we would have to make sure that it's even relevant to them at all. Like, we cannot just share it with them. And then they are like, well, I cannot read this. You know, it's not I cannot, I'm like, I'm not fluent in this language. So what's the point? Why did you say that? So I think it's definitely depend on all of this.'* – ID 10 (NGO)

Co-creation of programs was also viewed as a driver of acceptability and engagement with programs. The inclusion of peer leaders or champions was suggested to help drive program engagement, particularly for diverse communities. Furthermore, working through already trusted networks was seen as vital for future programs to be acceptable to adolescents.

> *'So it would have to feel like this was made, you know, in informed by people just like them? I think. So it's all again, going back into this is like, really, like you cannot make a service for adolescents without including them in the design in some way. And it cannot be tokenistic. Like they have to feel it in the way that they are seeing what it looks like, but the service looks like and for them to even learn about it.'* – ID 10 (NGO)

> *'…and so I guess, if they have already got a relationship of trust with that person, whether it's their peers, young people, you know, their peers, or the doctors or their parents. I think, I think the having someone that's reliable and trustworthy is probably key.'* – ID 8 (NGO)

Two barriers were identified to the successful implementation of digital health prevention programs at an individual level. Firstly, the balance in language and imagery to accommodate all diverse young people would need to be just right for them to engage with a digital health prevention program. The second barrier is competition with what is already available at schools and on social media.

> *'So if you can make it as interactive as possible, I would say that's the best thing. Yeah, the barrier would be too much or too little info. It's trying to get that right kind of nice size, nice imagery, nice colors across for them to really be like, oh, this is quite cool.'* – ID 5 (Health)

> *'But the biggest challenge, I think, is just going to be competing with what's already out there and trying to come up with a delivery approach that is engaging enough for them.'* – ID 6 (Other)

TABLE 2 Supporting quotes for themes identified from stakeholder interviews.

Existing initiatives are not fit for purpose
'Um, and I think there's little bits and pieces scattered in programs like reach out and stuff like that and mental health support also.' – ID 13 (Government)
'Um, so we have, we have like healthy eating programs just for young people who want to improve their nutrition. Sometimes it's incorporated with study groups as well, just so it's not food focused." – ID 16 (Youth Service)
'I would say that the main one would be anything that's through beyondblue… So pretty much mental health. That will be the main one that I would know of' – ID 15 (Education)
'Yeah, it's definitely one, I think, a strategy that can reach a lot more youth. Yeah, I guess it's just how sort of just how you pitch it and how you reach those youth? You know, I think that's always sometimes the hardest aspect and sort of ensuring that that you get, I guess, key stakeholders on board to sort of feed that through, as well to them.' – ID 9 (Government)
'Yes, yes. There aren't many complimentary to the little that is happening. Yes. For adolescents. Yeah. I think we, that is something that we must offer' – ID 2 (Health)
'I think there would be because I think, especially, you know, I think digital health can probably be seen as being cheaper to deliver and to target a much larger group of people than other types of health prevention programs.' – ID 6 (Other)
'Yeah, I think anything that can raise awareness of it. So whether it's training staff or, you know, training adults or other demographics as well, because then that way, they can push it through different channels and different streams and advocate for it' – ID 12 (NGO)
'Um certainly making teachers aware that these resources are available, and that they can possibly be integrated into teaching and learning programs not to be the way that students learn about that issue. But certainly, always, we are looking for students to develop the skills, have that health literacy and know where to go to get help. So by allowing, get letting teachers know what's available, and what's out there, then they can be saying, you know, putting those giving them information and say this is out there.' – ID 15 (Education)
'And then I think, I mean, depending on on how, how it was implemented, and what role someone within the school had to play, it's really about upskilling them on being able to, so if the, if there was complementary programs within the school, so through curriculum, for instance, then you'd be training up the teachers on how to implement those that teaching and learning effectively.' – ID 14 (Education)
'So how are you going to engage them if they do not really care about it for now, right?' – ID 20 (Community)
'and that's I think a little bit harder in some ways to get kids to engage in because most kids do not want to engage in something unless they think they need it.' – ID 17 (Education)
'So sort of seeking out those people who may need a program and then targeting something. That's how marketing works. So if health care services or health promotion services need to be competitive in the same way that the market is they need to use the same sort of strategies.' – ID 4 (Government)
Co-creation of programs with adolescents is critical for success
'So maybe incorporating that sort of thing where they can add their own friends, but also connect with other people as much about it.' – ID 6 (Other)
'I think the easiest way to work with them is not to try and go into those communities and run your own workshop, but rather you connect with those communities first and you find a community member that is, that is placed on formal leadership, right.' – ID 20 (Community)
'and also, if there's things that are made clear, like if it was inclusive of all young people, if they were … interpreter services available, if, you know, they felt like and I think they felt that there was transparency, and if people could give feedback, and they can see how what other people's experience with this services have been? …. So I feel like if these conditions aren't met, young people would not do that.' – ID 10 (NGO)
'Yeah, and as you know, language changes even like what's what interests kids and where it's cool to be, and what platforms it's cool to be on is constantly changing. Like, we cannot keep up' – ID 17 (Education)
'And how do you maintain that target audience? Especially as that target audience is kind of like shifting? How do you get them in once they are kind of spitting themselves out at the end? And then where do they go from there?' – ID 12 (NGO)
'Um, the biggest barriers would be I guess. Like I said, it, you are competing against so many other things that are online? So yeah, I think distraction does not sound like a very real barrier. But I feel like that's a big barrier for young people just actually getting onto their phone and using it' – ID 16 (Youth Service)
'I think having good engagement from adolescents themselves to help design the intervention, so that you sort of designing something that you know, is going to be appealing to them.' – ID 6 (Other)
'I think the health professionals understanding and the young people's perspective is quite different. Some, often, health professionals think that young people just will not engage in content, whereas really, there's a lot of engaging content out there. Young people are more focused on what they can trust. So I think perhaps, that's shifted.' – ID 4 (Government)
Digital health equity and unique technology challenges
'I think a lot, even if you do live regionally or rurally, I think most youth these days have a phone. Yeah, I think yeah, I think a lot. I think it's definitely probably one of the … a key strategy for accessibility.' – ID 9 (Government)
'So it's got to be a safe and well respected at the same time as being fun, edgy, different, changing all the time.' – ID 2 (Health)
'access to devices, access to you know, whether it's phones Wi Fi computers, you know, like the like, we take, I think, there you go, it's easy to take that connectivity for granted. There are a lot of different groups of young people, particularly socially excluded groups, young people, that's not a given.' – ID 7 (NGO)
'But then I think another thing, it, we have to remember is it cannot be used as a substitute for things that cannot, you know, be digitalized.' – ID 10 (NGO)
'young people have been yelling out for more like innovative supports around health' – ID 13 (Government)
'Especially for younger people, they feel a lot more comfortable doing things online. I cannot say that this is the same for people that are not fluent in English, and that are not digitally literate. But for young people. There's definitely an element of relief, a lot of the time when they know that they can access a service without having to go out, they can just pick up their phone or their computer and do something about it. Because it can be a lot less daunting.' – ID 10 (NGO)
'And now, you know, making that digitally accessible, can help in a lot of ways, but can create other barriers. So like I said, I think it'll be helpful to have different languages available and making it clear that this is like an inclusive space for people with different, different ethnicities, different sexualities' – ID 10 (NGO)

(Continued)

TABLE 2 (Continued)

'I mean, I think health is and well being it's sort of a private journey, in a way. So I guess that's the benefit that I can see that people can explore topics, and it might, you know, an information that that is what they need right now without necessarily going into a clinic or, you know, that sort of thing.' – ID 8 (NGO)
'I think, you know, some interaction with platforms that they are already using. It would be helpful. I do not know if that's necessarily possible. But it's, I think that's a way to improving engagement, if it can link in with, with things that they are already doing' – ID 6 (Other)
System level factors
'Monkey bureaucracies, slowness, rigidity, inflexibility, lack of imagination, people who are barriers who have never been involved…' – ID 2 (Health)
'It's harder for those to work these days because eyeballs are so distributed across different platforms and the algorithm means you do not always see the same stuff' – *ID 18 (Other)*
'Well, I think you, well, even within a New South Wales Health program, there's no one to refer it to, because they are all overwhelmed. Like, like, quite honestly, there aren't enough services' – ID 2 (Health)
'So I guess the answer would be like, it has to be constantly, like the impact has to be evaluated constantly. And there has to be a way to be able to see if it's making a change, you know, to know if anything has to be updated, or stopped at all.' – ID 10 (NGO)
'And so if it's kind of just info, being spat at them, it just will not work. They just, they really need things to kind of intrigue them or you know, even if it is, I do not know, it, even if it is something some information that you want them to know, the way that it's drawn across to them has to be interesting for them to even click on it sometimes. But I would say interactive is always going to be the best way.' – ID 5 (Health)
'So having a I guess like a support system behind that or you know somebody who can be a point of call. So if that young people do have questions that you have someone you can refer them to… So we can talk to and we can check in with them to see how the young person is going. And if from our side, we, when we are chatting or catching up with young people, we heard something concerning around the services, we can always directly send feedback to the services as well.' – ID 19 (Youth service)
'I think it's helpful for it to be linked with some sort of platform that goes forever. Because I think ultimately, what is successful on social media is repeat messaging. And I do not know how successful we are with sort of having a message given to them one or two times, and then having that implemented over the long term, I think really, you need to just have that repeat messaging. So I would almost think a very short, pro actual program, like a formal program would be quite short. But then the they would have access to content forever.' – ID 6 (Other)
'their interest change very rapidly, like they have a focus on something like it's the thing of the live class for 3 weeks, and then it goes into something else. So it may be that then, if the program is for, as long as 6 months, you might need to have a bit of dynamic' – ID 3 (Other)
'I suppose your issue is how can we do this as cost effective a way as possible, get maximum effect for the resourcing that we have. And if you can deal with a whole range of other if there's a range of other messages that are being done at the same time, rather than this is the eating disorder group. This is the alcohol group. This is a smoking group. This is the healthy lifestyles group. Maybe it would be better if those things were actually, if there was resourcing for all of them.' – ID 2 (Health)
'But then it's how do you get people to use that. And if that that mix of you need to have something that looks engaging, speaks their sort of language, you probably need to look at some sort of initial marketing, and promotions, or media type launch, to probably a mix of all really like you can do a media launch, and it gets 1 day of coverage. But you really need that sort of follow up social media sort of amplification as well.' – ID 11 (Youth Service)
'Yeah, and as you know, language changes even like what's what interests kids and where it's cool to be, and what platforms it's cool to be on is constantly changing. Like, we cannot keep up. We can, we can think we are on top of it here. And we know where they get hit with, like things like online bullying happening or whatever. But the next thing is, there's a whole new platform for them to work from that were totally unaware of. So I think there is a need to, to, to update relatively often, I've had so much update, but check relevance. And check it against your test. Who you are trying to get who you are trying to reach.' – ID 17 (Education)

The ongoing evaluation of programs was recognized by participants as essential for long-term successful implementation. Programs cannot be co-created and then left to run without evaluation, they must be dynamic to be able to accommodate any necessary changes, both in terms of the technology and the content. Individual feedback from adolescents will demonstrate the changing nature of their views and needs.

> *'And then like, obviously, you mentioned the research and evidence base is always evolving. So you have got and like young people, their service expectations, and where they are at in terms of the issues they are facing, or their approach to things that's evolving as well. So you have got like, all of these sort of cycles working at once, which is sort of kind of unique to the digital sort of space.'* – ID 11 (Youth Service)

By co-creating digital health prevention programs with young people and constantly evaluating them it may help to overcome the barriers identified and assist with the long-term successful implementation.

> *'If you if you want to target them, I think it's about like, trusting that they are the right person to inform how it should be.'* – ID 10 (NGO)

Digital health equity and unique technology challenges

Participants raised concerns around the equity of digital health prevention programs. This came from an access point of view, with the concern that adolescents who are most in need of these programs will not engage (e.g., rural and remote residing, culturally and linguistically diverse [CALD] populations). However, it also extended to incorporate the safety and trustworthiness of future programs.

> *'I guess there are those kind of equity issues around, you know, rural, regional, and just different environments, and how, depending on which environment you are, you might be more susceptible to different mental health issues or, you know, access to food, and obesity.'* – ID 12 (NGO)

> *'You do need that massive drawing area, because what meets the needs of a kid living in a city is not going to meet the needs of the kid living in a country town or living in a regional part of Australia or, or in an isolated part of Australia'* – ID 17 (Education)

> *'But if it's about a particular health message, they may receive it differently if it's from someone that had that medical background, or someone that they already trusted in that sort of space.'* – ID 8 (NGO)

The accessibility of digital health prevention programs was identified as both a barrier and enabler. Being digital provides access in a modern context, especially as adolescents can be more comfortable with doing things online. However, it must be ensured that the program is accessible to all and is not widening the digital divide.

> *'Well, they are asking for it! I think the strengths of a digital health approach that is it allows health access to be more functional in the modern world. Like, it's been a bit of a slow pull, getting the medical system to digitize and it's just unnecessarily slow, like the whole world is technological now, just that it's really important that we invest in upgrading the health system in that way. It allows flexibility for young people to be able to access health independent of their parents or carers, which is really important because a lot of you know, especially around like mental health and, and sexual health and drugs and stuff like that a lot of young people do not, wont access health system because they have to go through their parents to ask about those tricky subjects.'* – ID 13 (Government)

> *'I would say from a health … equity point of view and working with people low socio-economic status and from cultural, linguistically diverse communities, it's more of whether the technology that you are putting up is suitable for the devices that they have access to, right? It's pretty much a given that everyone has access to a mobile device these days, but it's the how high powered that device is'* – ID 20 (Community)

When discussing implementation at an individual level, two main enablers were identified. Firstly, it was recognized that for adolescent's health and wellbeing is a private journey, and by providing access to preventive health information online from a reputable source it may be better than online sources that they are currently accessing. Secondly, adolescents were identified as a captive audience through their presence at schools and on social media, these would cast a wide net over the adolescent population and be ideal entry points to a digital health prevention program.

> *'And I would say also, digital health prevention, prevention of preventative space is really good if there are things online that you want to ask that you do not want other people to know about. So especially what I hear through a lot of our young people is that they will go to Reddit and other apps that to source their information that's a bit worrying in some ways that that's where they go to so educational programs'* – ID 5 (Health)

> *'That you have got a captive audience, that's the first thing that yeah, that there's opportunities for, for teaching and learning to sit alongside it, that's, you know, that they can learn about what they are doing and the outputs of, of the program.'* – ID 14 (Education)

For implementation at a setting level, the first enabler which was identified by participants was that the platform on which the program is delivered needs to be credible, innovative and in spaces that adolescents already engage with. Secondly, it was suggested that the program could be multicomponent to increase engagement and provide repeat messaging across different platforms. Finally, it needs to be flexible to adapt with the ever-changing digital world.

> *'And there's a lot of money again, government it's a lot of money into all kinds of digital solutions that aren't, you know, they have they are not tested, they do not work and there's a lot of money that went into them. And that's, that's terrible when we see that happening. So yeah, it's about doing all of that, that kind of piloting and testing first. And then once it's right then making the commitment to make it sustainable.'* – ID 7 (NGO)

> *'Yeah. It's hard because the digital world changes so quickly, and what's cool and trendy one day, and I mean, even possibly looking at this is a thing that embedding it in some of the things that kids commonly use, so messages that come through on Instagram or, or Snapchat…'* – ID 17 (Education)

System level factors

System level factors extends to the technology systems which deliver the program, the health system and current available services and other resources which may be needed for successful implementation of digital health prevention programs. Inflexibility of the platform was one of the setting level implementation barriers identified by participants. It was acknowledged that whatever platform used would need to be able to keep up with technology changes. Furthermore, some participants raised the issue of bureaucracies that exist within government and the health system which may hinder future partnerships and implementation of digital health prevention programs.

> *'The other thing that kids I find increasingly used to the laptops as well. So just that access on across platforms, I guess, the phone, but also kids will get online and like say I suppose the app though, I suppose the phone is the app level. So that's a strength in that you can put it there, but you can also have I suppose computer compatible and proper technology, computer compatible programs that they can access from that level too.'* – ID 17 (Education)

> *'So if you want, for example, [xxx] to be, to have their logo and be a part of that process to lend their like respectability and, and*

> *reputation to the process that can be a long winded, very bureaucratic process. It's very resource heavy.'* – ID 13 (Government)

Another implementation barrier which was identified at a setting level is that the health system is not oriented toward adolescents, considering there are not enough services available for them and the services which are available may not suit their needs. Finally, the resourcing needed to run a digital health prevention program for adolescents was seen as a barrier to successful implementation.

> *'And a lot of young people are often transparent to the health system, the health system is not oriented toward them, will not put the effort into them, and will not bother to speak with them deliver the services for them, actually put a bit of effort into getting something that will appeal to them.'* – ID 2 (Health)

> *'I think you just need it needs to be adequately funded to be able to pay for advertising and have the staffing who can you know, create new content regularly to keep it relevant. I think that's going to be the biggest challenge.'* – ID 6 (Other)

> *'And I'm like the outlier if it's a always on* versus *a supported, like person behind service or not sort of thinking about, well, what hours are young people going to access the service and it might not be nine to five, Monday to Friday.'* – ID 11 (Youth Service)

To combat these barriers several solutions were suggested by participants. The first is that constant evaluation of the program is needed. This can be through various means including through back-end data from the digital platform and individual participant feedback to assess impact and measure health outcomes.

> *'Yeah, I think like, it's all backend stuff, right? Because you'd want to have ability, and you'd want to like if it was an app, you'd want to mimic on the things that work. So you know, the ability to like something, the amount of time that somebody's watching the video or engagements'* – ID 12 (NGO)

> *'And then because digital moves so quickly, it could be like 6 months, or a year and the world has moved on. So I think it's like embedding that sort of strong feedback loops, both with users themselves, and like, a sort of broader evaluation like program evaluation and outcomes.'* – ID 11 (Youth Service)

The ability of the platform to be adaptive to technology and infrastructure changes was recognized as imperative for long term implementation. Participants provided examples of the wavering engagement from adolescents when the program was not flexible.

> *'Oh well, they probably used it for a couple of years and the main drop off was again it comes to those design things, people update their phones it's they did not it was made with one-off funding so they did not have the funding to keep updating it. So what began is students started to start. It started to have bugs and those sorts of things. And it's, you know, and so it started to be like, oh, hang on a second, only half the students seem to be able to access it, you know. And so it became something that over time it just did not have that longevity.'* – ID 18 (Other)

> *'You know, I think it would need to be reviewed at least every year or two, because technology is moving so fast that, you know, when I first started looking at social media, like Instagram was the most popular app for adolescents. And a year or two later, it was TikTok, and Snapchat. And so to remain relevant, I think you probably have to review the digital platform every year just to see where things are going.'* – ID 6 (Other)

Various resources were identified by participants as necessary if a digital health prevention program is to be implemented. Firstly, enough funding is needed to ensure that the program is continuously available and that it is delivered in a way which is cost-effective, which may take a multicomponent approach. Furthermore, there is a need to consider the demand that may be placed on other services through referral from the digital health prevention program.

> *'So if there's going to be like action messages to the adolescent, or if there's going to be support in, you know, if you are feeling like this, here are the services that are available that you can contact, I guess making sure that those service providers are well aware of the demand that could be created.'* – ID 12 (NGO)

> *'the biggest thing we hear from young people, and again, it's not just in this area, but in many areas, really great programs come along, and they are awesome. And then the funding runs out, and they stop. And that's really frustrating for young people. And it's really difficult if it's something that they thought was really valuable.'* – ID 7 (NGO)

For successful maintenance of digital health prevention programs, participants identified that partnerships would be necessary. This would be a potential solution to the issue above around the demand placed on other service providers. Secondly, partnerships will help not only with the launch of a future program, but also with the ongoing amplification and sustainability. This was suggested by stakeholders to occur on social media.

> *'I would think maybe a shorter program that's only 6, 3 months or something short, that then they can link into a YouTube channel or article … or something that provides them with information and content forever, until that goes out of fashion. And then you switch to the new the new platform and whatever it is'* – ID 6 (Other)

> *'So having a I guess like a support system behind that or you know somebody who can be a point of call. So if that young people do have questions that you have someone you can refer them to… So we can talk to and we can check in with them to see how the young person is going. And if from our side, we, when we are chatting or catching up with young people, we heard something concerning around the services, we can always directly send feedback to the services as well.'* – ID 19 (Youth service).

Discussion

This qualitative study found there was broad support from stakeholders across sectors for digital health prevention programs targeting adolescents. Using the RE-AIM framework, new insights were uncovered under four main themes: current digital health initiatives are not fit for purpose, co-creation of programs with adolescents is critical for success, digital health equity and unique technology challenges and system level factors. Stakeholders had limited knowledge of current initiatives that had a specific focus on prevention of chronic diseases and provided unique perspectives on barriers and enablers to the implementation of digital health prevention programs, and strategies to ensure their long-term success. Co-creation with adolescents was viewed by stakeholders as essential for the future development and implementation of digital health prevention programs. It was also recognized that digital health equity must be considered, along with the unique challenges that technology brings. Finally, system level factors including resources and digital infrastructure must be considered for success.

Results from global initiatives (e.g., 1point8 for change) reveal that affordable, high-quality adolescent health and wellbeing services through digital platforms are important to young people (22). Adolescents are digital natives and early adopters of technology; therefore, delivery of these services digitally is a scalable and equitable solution. It is important to recognize that digital divides exist, yet they generally mirror socio-economic divides (23). Therefore, to address equity in future digital health prevention programs, it will be important to address socio-economic factors within them. Systematic review evidence has also shown that adolescents are receptive to the use of digital health for preventive services (24). However, successful implementation of these services does not come without challenges. A scoping review aimed to uncover challenges on the use of digital health prevention programs among adolescents and found three key challenges were the disconnection between digital health and clinical preventive care, threats to the privacy and security of young people, and trouble finding valuable digital health programs for young people (25). These findings are not unique to high income countries, a systematic review found that the sustainability of digital health interventions in low- and middle-income countries is also complex and multidimensional (26). However, digital health solutions are promising in low- and middle-income countries, where mobile phones are used for internet access (27). The results from this study provide important findings from stakeholder's perspectives to help combat some of these previously identified challenges.

A key finding from this study was that stakeholders viewed the co-creation of digital health prevention programs to be essential for their success. Though the word 'co-design' was commonly used by stakeholders within interviews, co-creation is a more appropriate term to describe the true meaning of their intention to involve adolescents. Co-creation refers to the collaborative nature of problem solving from problem identification through to implementation and evaluation (28). Co-creation of research has been found to improve health related outcomes among adults (29), yet limited research is available to understand how this extends to adolescent health outcomes. Adolescent engagement in research often occurs once research design and protocols are in place (30). A scoping review investigating adolescent participation in chronic disease prevention research found only 11% of studies engaged adolescents in all five stages of the research process (31). Co-creation can ensure that programs are engaging and provide value, and that they represent views from all diverse young people. However, diverse young people may have different requirements or preferences, thus it is important that the parameters of resources and funding are outlined from the start (32). By creating safe, trustworthy, and inclusive environments for adolescents to co-create solutions together with researchers and stakeholders, there is likely to be greater impact and long-term success.

Another finding from this study is that stakeholders did not consider digital health prevention programs as a stand-alone setting for delivering preventive health care, highlighting the need to address system level factors in future program development and implementation. Though the Australian health care system performs well on international standards, it has been recognized that it is too complex to navigate with multiple providers at local, state and national levels (33). This results in a system which is failing to provide equitable access to all. Though public views have improved over time, access to care is still recognized as an area for improvement (34). Recommendations from prior research have highlighted that technology should be fully utilized by health services to promote engagement as well as health care (35). The Australian school system was also considered, however up to 20% of students are consistently disengaged (36), and previous digital health preventive programs within a school setting have been unsuccessful in modifying chronic disease risk factors (37). Furthermore, a prior scoping review called for more research to successfully implement digital health programs to achieve primary prevention in settings including formal organizations such as schools and healthcare facilities, and less formal settings including households and neighborhoods (38). Stakeholders in this study broadly supported the implementation of digital health prevention programs and recognized that they are a way to provide equitable access in a modern context. Partnerships within the health care system, schools and related services are potential solutions for successful long-term implementation of digital health prevention programs for adolescents.

This study found that working through already trusted networks would be key to successful implementation of digital health prevention programs for adolescents. A WHO-UNICEF-Lancet Commission found that assurance of data privacy and security is key to digital innovations (39, 40), and reviews have suggested to prioritize ethical research which addresses data privacy (40). Adolescents are particularly vulnerable in the digital world for a multitude of reasons. They are forming online identities while their offline identities are still forming, thus their usage of technology and information sharing is potentially at risk (41). Also, digital health literacy skills of adolescents need to be considered so that they can confidently evaluate the information delivered (42). Therefore, it is imperative that digital health prevention programs address these vulnerabilities within the digital infrastructure. The co-creation of programs with adolescents and use of peer champions may assist to address this issue, so they can learn through peers that the digital health prevention program is safe and trustworthy to use.

A strength of this study is that we interviewed stakeholders across a broad range of sectors including government, health, community, education, NGOs and youth services. Though stakeholders were from

a broad range of sectors, there was a small sample in some sectors and did not gain depth within some sectors which may be a limitation of the study. A further limitation is that we only interviewed stakeholders from three states and territories in Australia. Despite this, clear themes were evident in the data collected and some of the stakeholders operated at a national level and thus gave insights from across Australia. Another potential limitation to the study is that the findings are unique to the context and may not be widely generalizable beyond Australia. However, similar insights have been uncovered in other global studies (25, 26, 43). Finally, this study only demonstrates the views of stakeholders and does not represent the views of adolescents. Future research may strive to confirm these results with adolescents to understand whether they identify any additional barriers or enablers to implementation.

Conclusion

This qualitative study found that there were broad levels of support from stakeholders for the implementation of digital health prevention programs for adolescents. Through using the RE-AIM Framework for implementation, four overarching themes were found. Firstly, existing digital health initiatives are not fit for purpose. For successful implementation of future programs, stakeholders identified that co-creation of programs with adolescents is essential, digital health equity needs to be considered and system level factors should be addressed. Research is needed to apply these insights into future program development to accelerate widespread implementation of digital health prevention programs.

Data availability statement

The datasets presented in this article are not readily available because individual participant data will not be made available. Participant quotes can be found in the manuscript and in Table 2. The discussion guide is available as Appendix 2. Requests to access the datasets should be directed to rebecca.raeside@sydney.edu.au.

Ethics statement

The studies involving humans were approved by The University of Sydney Human Research Ethics Committee (approval number 2022/778). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

RR: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing. AT: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing. KAS: Conceptualization, Writing – original draft, Writing – review & editing. MK: Conceptualization, Writing – original draft, Writing – review & editing. SM: Conceptualization, Writing – original draft, Writing – review & editing. LG: Conceptualization, Writing – original draft, Writing – review & editing. KEC: Conceptualization, Writing – original draft, Writing – review & editing. JS: Conceptualization, Writing – original draft, Writing – review & editing. LL: Conceptualization, Writing – original draft, Writing – review & editing. KS: Conceptualization, Writing – original draft, Writing – review & editing. JR: Conceptualization, Funding acquisition, Methodology, Supervision, Writing – original draft, Writing – review & editing. SRP: Writing – original draft, Writing – review & editing, Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Supervision.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This study received funding from the Australian Government Department of Health Medical Research Future Fund Primary Care Grant (2006315). RR is funded by a NHMRC SOLVE-CHD [GNT1182301] Primary and Supplementary Research Scholarship. JR is funded by a NHMRC Investigator Grant (Leadership) [GNT2007946]. SP is supported by a National Heart Foundation Future Leader Fellowship [Grant number: 106646]. The funding source had no involvement in the study design, data collection, data analysis, interpretation of data, writing of the manuscript and decision to submit for publication. The authors were not precluded from accessing data in the study, and they accept responsibility to submit for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2024.1389739/full#supplementary-material

References

1. Patton GC, Sawyer SM, Santelli JS, Ross DA, Afifi R, Allen NB, et al. Our future: a lancet commission on adolescent health and wellbeing. *Lancet*. (2016) 387:2423–78. doi: 10.1016/S0140-6736(16)00579-1

2. Biswas T, Townsend N, Huda MM, Maravilla J, Begum T, Pervin S, et al. Prevalence of multiple non-communicable diseases risk factors among adolescents in 140 countries: a population-based study. *eClinicalMedicine*. (2022) 52:101591. doi: 10.1016/j.eclinm.2022.101591

3. World Health Organization. *Global accelerated action for the health of adolescents (AA-HA!): Guidance to support country implementation. 2nd* ed. Geneva: World Health Organization. (2023).

4. Australian Government Department of Health. *National action plan for the health of children and young people 2020–2030*. Canberra, Australia: Australian Government Department of Health (2019).

5. World Health Organization. *Youth-centred digital health interventions: A framework for planning, developing and implementing solutions with and for young people*. Geneva: World Health Organization. (2020).

6. Garney W, Wilson K, Ajayi KV, Panjwani S, Love SM, Flores S, et al. Social-ecological barriers to access to healthcare for adolescents: a scoping review. *Int J Environ Res Public Health*. (2021) 18:4138. doi: 10.3390/ijerph18084138

7. Baltag V, Sawyer SM. Quality health care for adolescents In: *International handbook on adolescent health and development*. Eds. A. L. Cherry, V. Baltag and M. E. Dillon Cham: Springer (2017)

8. Rose T, Barker M, Maria Jacob C, Morrison L, Lawrence W, Strömmer S, et al. A systematic review of Digital interventions for improving the diet and physical activity behaviors of adolescents. *J Adolesc Health*. (2017) 61:669–77. doi: 10.1016/j.jadohealth.2017.05.024

9. Kouvari M, Karipidou M, Tsiampalis T, Mamalaki E, Poulimeneas D, Bathrellou E, et al. Digital health interventions for weight management in children and adolescents: systematic review and meta-analysis. *J Med Internet Res*. (2022) 24:e30675. doi: 10.2196/30675

10. Australian Government Department of Health. *National Preventive Health Strategy 2021–2030*. Canberra, ACT, Australia: Australian Government Department of Health (2021).

11. Partridge SR, Redfern J. Strategies to engage adolescents in Digital health interventions for obesity prevention and management. *Healthcare (Basel)*. (2018) 6:70. doi: 10.3390/healthcare6030070

12. Wies B, Landers C, Ienca M. Digital mental health for young people: a scoping review of ethical promises and challenges. *Front. Digital Health*. (2021) 3:697072. doi: 10.3389/fdgth.2021.697072

13. Rosenbaum S, Tiedemann A, Stanton R, Parker A, Waterreus A, Curtis J, et al. Implementing evidence-based physical activity interventions for people with mental illness: an Australian perspective. *Australas Psychiatry*. (2015) 24:49–54. doi: 10.1177/1039856215590252

14. Falkner NH, Neumark-Sztainer D, Story M, Jeffery RW, Beuhring T, Resnick MD. Social, educational, and psychological correlates of weight status in adolescents. *Obes Res*. (2001) 9:32–42. doi: 10.1038/oby.2001.5

15. Department of Health. *National obesity strategy 2022–2032*. Canberra, Australia: Government of Australia (2022).

16. Psihogios AM, Lane-Fall MB, Graham AK. Adolescents are still waiting on a Digital health revolution: accelerating research-to-practice translation through Design for Implementation. *JAMA Pediatr*. (2022) 176:545–6. doi: 10.1001/jamapediatrics.2022.0500

17. Laird Y, Manner J, Baldwin L, Hunter R, McAteer J, Rodgers S, et al. Stakeholders' experiences of the public health research process: time to change the system? *Health Res Policy Syst*. (2020) 18:83. doi: 10.1186/s12961-020-00599-5

18. World Health Organization. *Regional Office for the Western Pacific. Module 2: Stakeholder analysis and networks. In: Health service planning and policy-making: A toolkit for nurses and midwives*. Manila: WHO Regional Office for the Western Pacific (2005).

19. Glasgow RE, Vogt TM, Boles SM. Evaluating the public health impact of health promotion interventions: the RE-AIM framework. *Am J Public Health*. (1999) 89:1322–7. doi: 10.2105/AJPH.89.9.1322

20. Glasgow RE, Harden SM, Gaglio B, Rabin B, Smith ML, Porter GC, et al. RE-AIM planning and evaluation framework: adapting to new science and practice with a 20-year review. *Front Public Health*. (2019) 7:64. doi: 10.3389/fpubh.2019.00064

21. Holtrop JS, Rabin BA, Glasgow RE. Qualitative approaches to use of the RE-AIM framework: rationale and methods. *BMC Health Serv Res*. (2018) 18:177. doi: 10.1186/s12913-018-2938-8

22. PMNCH. Agenda for Action for Adolescents 2023. (2023). Available at: https://www.1point8b.org/agendaforactionforadolescents

23. UNICEF. State of the World's Children (2017) Children in a Digital World 2017 Available at: https://www.unicef.org/reports/state-worlds-children-2017

24. Ferretti A, Hubbs S, Vayena E. Global youth perspectives on digital health promotion: a scoping review. *BMC Digital Health*. (2023) 1:25. doi: 10.1186/s44247-023-00025-0

25. Wong CA, Madanay F, Ozer EM, Harris SK, Moore M, Master SO, et al. Digital health technology to enhance adolescent and young adult clinical preventive services: affordances and challenges. *J Adolesc Health*. (2020) 67:S24–33. doi: 10.1016/j.jadohealth.2019.10.018

26. Kaboré SS, Ngangue P, Soubeiga D, Barro A, Pilabré AH, Bationo N, et al. Barriers and facilitators for the sustainability of digital health interventions in low and middle-income countries: a systematic review. *Front Digit Health*. (2022) 4:1014375. doi: 10.3389/fdgth.2022.1014375

27. GSMA. The State of Mobile Internet Connectivity Report 2023-2024. (2024). Available at: https://www.gsma.com/r/somic/

28. Vargas C, Whelan J, Brimblecombe J, Allender S. Co-creation, co-design, co-production for public health – a perspective on definitions and distinctions. *Public Health Res Pract*. (2022) 32:e2022. doi: 10.17061/phrp3222211

29. Halvorsrud K, Kucharska J, Adlington K, Rüdell K, Brown Hajdukova E, Nazroo J, et al. Identifying evidence of effectiveness in the co-creation of research: a systematic review and meta-analysis of the international healthcare literature. *J Public Health*. (2019) 43:197–208. doi: 10.1093/pubmed/fdz126

30. Swist T, Collin P, Nguyen B, Davies C, Cullen P, Medlow S, et al. Guiding, sustaining and growing the public involvement of young people in an adolescent health research community of practice. *Health Expect*. (2022) 25:3085–95. doi: 10.1111/hex.13616

31. Mandoh M, Redfern J, Mihrshahi S, Cheng HL, Phongsavan P, Partridge SR. Shifting from tokenism to meaningful adolescent participation in research for obesity prevention: a systematic scoping review. *Front Public Health*. (2021) 9:789535. doi: 10.3389/fpubh.2021.789535

32. Thabrew H, Fleming T, Hetrick S, Merry S. Co-design of eHealth interventions with children and young people. *Front Psych*. (2018):481:9. doi: 10.3389/fpsyt.2018.00481

33. Calder R, Dunkin R, Rochford C, et al. *Australian health services: too complex to navigate*. Victoria University, Melbourne, VIC, Australia: Mitchell Institute (2019).

34. Ellis LA, Pomare C, Gillespie JA, Root J, Ansell J, Holt J, et al. Changes in public perceptions and experiences of the Australian health-care system: a decade of change. *Health Expect*. (2021) 24:95–110. doi: 10.1111/hex.13154

35. Kang MRJ, Sanci L, Steinbeck K, Jan S, Hawke C, Luscombe G, et al. *Access 3: young people and the health system in the digital age - final research report*. Department of General Practice Westmead, the University of Sydney and the Australian Centre for Public and Population Health Research, the University of Technology Sydney, Australia. (2018).

36. Hancock K, Zubrick S, Nichols T. *Children and young people at risk of disengagement from school: literature review*. Perth, Australia: Commissioner for Children and Young People. (2015).

37. Champion KE, Newton NC, Gardner LA, Chapman C, Thornton L, Slade T, et al. Health4Life eHealth intervention to modify multiple lifestyle risk behaviours among adolescent students in Australia: a cluster-randomised controlled trial. *Lancet Digital Health*. (2023) 5:e276–87. doi: 10.1016/S2589-7500(23)00028-6

38. Stark AL, Geukes C, Dockweiler C. Digital health promotion and prevention in settings: scoping review. *J Med Internet Res*. (2022) 24:e21063. doi: 10.2196/21063

39. The Lancet Digital Health. Child and adolescent health in the digital age. *Lancet Digital Health*. (2020) 2:e102. doi: 10.1016/S2589-7500(20)30029-7

40. Clark H, Coll-Seck AM, Banerjee A, Peterson S, Dalglish SL, Ameratunga S, et al. A future for the world's children? A WHO–UNICEF–Lancet Commission. *Lancet*. (2020) 395:605–58. doi: 10.1016/S0140-6736(19)32540-1

41. Iarani ST, Matheny ME, Matlow R, Whicher D. Equity, inclusivity, and innovative Digital technologies to improve adolescent and young adult health. *J Adolesc Health*. (2020) 67:S4–6. doi: 10.1016/j.jadohealth.2020.05.014

42. Taba M, Allen TB, Caldwell PHY, Skinner SR, Kang M, McCaffery K, et al. Adolescents' self-efficacy and digital health literacy: a cross-sectional mixed methods study. *BMC Public Health*. (2022) 22:1223. doi: 10.1186/s12889-022-13599-7

43. Bergin AD, Vallejos EP, Davies EB, Daley D, Ford T, Harold G, et al. Preventive digital mental health interventions for children and young people: a review of the design and reporting of research. *NPJ Digital Med*. (2020) 3:133. doi: 10.1038/s41746-020-00339-7

Appendix 1: Consolidated criteria for reporting qualitative research (COREQ) Checklist

Domain 1: Research team and reflexivity	
Personal Characteristics	
33. Interviewer/facilitator: Which author/s conducted the interview or focus group?	All interviews were conducted by RR and AT
34. Credentials: What were the researcher's credentials? E.g. PhD, MD	RR holds a MPH and BBiomedSc, AT holds a MPH and B. Global Studies
35. Occupation: What was their occupation at the time of the study?	RR is a Research Associate, AT is a Research Officer
36. Gender: Was the researcher male or female?	RR and AT both identify as female.
Experience and training	
37. What experience or training did the researcher have?	RR has organised, supervised and taken notes for >15 focus groups, led 5 focus groups and conducted >20 individual semi-structured interviews with research participants. AT has organised, supervised and taken notes for >5 focus groups and conducted >15 individual semi-structured interviews with research participants.
Relationship with participants	
38. Relationship established: Was a relationship established prior to study commencement?	RR had no prior relationships with any of the participants who took part. AT had a prior relationship with two of the participants.
39. Participant knowledge of the interviewer: What did the participants know about the	None of the participants knew the interviewer prior to the interviews.

researcher? e.g. personal goals, reasons for doing the research	All participants read and signed e-consent forms therefore they knew the reasons for conducting the research.
40. Interviewer characteristics: What characteristics were reported about the interviewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	No characteristics were reported
Domain 2: study design	
Theoretical framework	
41. Methodological orientation and Theory: What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	Deductive content analysis within the RE-AIM Framework for Implementation
Participant selection	
42. Sampling: How were participants selected? e.g. purposive, convenience, consecutive, snowball	Convenience and snowball
43. Method of approach: How were participants approached? e.g. face-to-face, telephone, mail, email	Participants were invited via email.
44. Sample size: How many participants were in the study?	51 participants were invited 19 interviews were conducted
45. Non-participation How many people refused to participate or dropped out? Reasons?	32 participants did not respond to the email invitation.
Setting	
46. Setting of data collection: Where was the data collected? e.g. home, clinic, workplace	Online using Zoom teleconference
47. Presence of non-participants: Was anyone else present besides the participants and researchers?	No

48. Description of sample What are the important characteristics of the sample? e.g. demographic data, date Data collection	Demographic data
49. Interview guide: Were questions, prompts, guides provided by the authors? Was it pilot tested?	Questions were asked by the interviewer but not provided to participants. Interview guide was not pilot tested.
50. Repeat interviews: Were repeat interviews carried out? If yes, how many?	Yes, 19 interviews were conducted.
51. Audio/visual recording: Did the research use audio or visual recording to collect the data?	Audio recording was used to collect data via Zoom teleconference and iPhone voice memos
52. Field notes: Were field notes made during and/or after the interview or focus group?	Yes, after.
53. Duration: What was the duration of the interviews or focus group?	45 minutes
54. Data saturation: Was data saturation discussed?	Yes
55. Transcripts returned: Were transcripts returned to participants for comment and/or correction?	No
Domain 3: analysis and findings	
Data analysis	
56. Number of data coders: How many data coders coded the data?	Two data coders with discrepancies checked by third independent coder
57. Description of the coding tree: Did authors provide a description of the coding tree?	Yes
58. Derivation of themes: Were themes identified in advance or derived from the data?	Derived from the data.

59. Software: What software, if applicable, was used to manage the data?	Transcripts produced in Microsoft Word, thematic analysis in NVivo (1.7)
60. Participant checking: Did participants provide feedback on the findings?	No
Reporting	
61. Quotations presented: Were participant quotations presented to illustrate the themes / findings? Was each quotation identified? e.g. participant number	Yes
62. Data and findings consistent: Was there consistency between the data presented and the findings?	Yes
63. Clarity of major themes: Were major themes clearly presented in the findings?	Yes
64. Clarity of minor themes: Is there a description of diverse cases or discussion of minor themes?	Yes

Appendix 2. Semi-Structured Interview Guide: Digital Health Prevention Programs for Adolescents Relating to Lifestyle Health Behaviours

Interviewer to briefly introduce themselves

Inform the need to audio record the session and remind interviewees the session will not be video recorded so they can keep their cameras on if they would like to and feel comfortable to do so.

Explain that they can withdraw from the interview at any time; however, any contribution to the discussion prior to withdrawal cannot be removed from the recording or written transcript.

Introductions

Explain the purpose of the project and bring up respectful discussion

Main purpose

Explain purpose of project

We are researchers from The University of Sydney conducting research into digital health prevention programs for adolescents relating to lifestyle health behaviours (physical activity, diet, screen time, sleep, body image etc). National frameworks such as the National Preventive Health Strategy and National Action Plan for Young People recommend digital health strategies, and we are aiming to align our research within these. We have conducted a stakeholder mapping process to identify key stakeholders in lifestyle health promotion for adolescents (13-18 years), of which your organisation has been identified. We are seeking to understand the perspectives of key stakeholders who may influence the success and/or implementation of digital health prevention programs for adolescents relating to lifestyle health behaviours.

'Digital health prevention programs' refers to using a range of technologies (mobile health and applications, telehealth, wearable devices, and artificial intelligence) to protect, promote and sustain the population's health.

‘Prevention’ refers to decreasing the risk, chance or likelihood of an individual developing obesity or mental illness.

The interview will take a maximum of 45 minutes of your time.

Questions for health/education organisations:

1. What does ‘digital health’ mean to you?

   Prompt: What digital modalities do you think are most useful for health prevention?
2. What do you think the most important health prevention messages are for adolescents?

Initiatives are defined as any health services or programs that are run routinely or periodically or health resources that are publicly available

3. Within your organisation, can you think of any adolescent-specific health prevention initiatives that are currently available and what are they?

   Prompt: If yes, what is the current reach/uptake of these initiatives?

   Prompt: Do you think that a digital health prevention program would be complementary to any existing initiatives within your organisation? Why/Why not?

   Prompt: How well do you think your organisation is doing with this initiative? Do you have any data on this that you can share?

Reach

4. How many adolescents do you think are currently reached by health prevention/digital health prevention programs?
5. What percentage of adolescents do you believe can be reached through a digital health prevention program?
6. Do you think adolescents who come through your organisation would sign up for a digital health prevention program of their own accord?

7. What do you think would be the best way(s) to get adolescents to sign up to a digital health prevention program?

   Prompt: Flyers in waiting room, presented by staff, newsletter distribution, parent/guardians, social media, as part of school curriculum, in health education classes

Effectiveness

8. Would it be feasible within your organisation to collect data on outcomes to understand whether a digital health prevention program was effective?

Adoption

9. Do you think there would be support within your organisation for a digital health prevention program for adolescents? Why/why not?
10. Do you think staff within your organisation would offer this sort of program to adolescents who come through? Why/why not?

    Prompt: What sort of training or staff support do you think would be needed to implement such a program?
11. What could be done to improve the uptake of a digital health prevention program for adolescents?

Implementation

12. What do you think are the greatest strengths your organisation has for implementing a digital health prevention program for adolescents?
13. What do you forecast to be the biggest barriers or challenges of implementing a digital health prevention program for adolescents?

    Prompt: What resources do you think your organisation would need to be able to support the implementation of digital health prevention programs?

Maintenance

14. How long do you think a digital health prevention program for adolescents should run for?

    Prompt: How often do you think a program such as this should be updated?

    Prompt: Do you think that adolescents should be able to access these programs more than once?

    Prompt: Do you think your organisation would be willing to trial or pilot a digital health prevention program? Why/why not?
15. What systems or support would your organisation need to collect data beyond the research phase?

Questions for youth advocacy groups:

1. What does 'digital health' mean to you?

   Prompt: What digital modalities do you think are most useful for health prevention?
2. What do you think the most important health prevention messages are for adolescents?

Initiatives are defined as any health services or programs that are run routinely or periodically or health resources that are publicly available

3. Can you think of any adolescent-specific health prevention initiatives that are currently available? If yes, what are they?

   Prompt: Do you think that a digital health prevention program would be complementary to any existing health prevention initiatives you are currently running? (e.g. in-person workshops) Why/Why not?
4. Prompt: How well do you think your organisation is doing with this initiative? Do you have any data on this that you can share?

Reach

5. How many adolescents do you think are currently reached by health prevention/digital health prevention programs?
6. What percentage of adolescents do you believe can be reached through a digital health prevention program?
7. Do you think adolescents would sign up for a digital health prevention program of their own accord? Why/why not?
8. What do you think would be the best way(s) to get adolescents to sign up to a digital health prevention program?

   Prompt: Flyers, presented by staff, newsletter distribution, parent/guardians, social media

Effectiveness

9. Are there any ways that your group would be able to assess whether a digital health prevention program is effective?
10. What kind of youth involvement do you think is necessary for a digital health prevention program to be effective?

Adoption

11. Do you think there would be support for a digital health prevention program from adolescents? Why/why not?
12. Do you think staff within your organisation would suggest this sort of program to adolescents who come through? Why/why not?
13. What kind of youth consultation could be done to improve the uptake of a digital health promotion program for adolescents?

Implementation

14. What do you think are the greatest strengths your organisation has for implementing a digital health prevention program for adolescents?

15. What do you forecast to be the biggest barriers of implementing a digital health prevention program for adolescents in either healthcare or community settings?

Maintenance

16. How long do you think a digital health prevention program for adolescents should run for?

    Prompt: How often do you think a program such as this should be updated?

    Prompt: Do you think that adolescents should be able to access these programs more than once?

    Prompt: Do you think your organisation would be willing to trial or pilot a digital health prevention program? Why/why not?

17. What kind of youth involvement strategies should be in place to maintain the relevance and currency of digital health prevention programs?

Chapter One

Introduction

Chapter Two

Systematic Review with Meta-Analysis

Chapter Three

Qualitative Study with Adolescents

HEALTH4ME

Chapter Four

Co-Design of Health4Me

Chapter Five

Health4Me RCT Protocol

Chapter Six

Health4Me Recruitment

Chapter Seven

Qualitative Study with Stakeholders

Chapter Eight

Discussion and Conclusions

CHAPTER EIGHT: Discussion

This thesis explores the use of contemporary digital health interventions to improve adolescent health and wellbeing outcomes. The outcomes advance the understanding of adolescent health promotion in the digital era. Each chapter in this thesis has a specific discussion on the findings of that chapter within the context of relevant research. This chapter summarises the key findings and future directions arising from this thesis and considers the strengths and limitations.

Overall, this thesis provides evidence to advance the use of digital technologies to improve adolescent health and wellbeing in the digital era. Meta-analyses evidence found that there was a small, yet non-significant positive effect of digital health interventions which target health risk behaviours on improving the mental health or wellbeing of adolescents (Chapter Two). In addition, in the qualitative study, adolescents reported an abundance and complexity of preventive health information online. They desire preventive health information that is appealing, credible, relevant, and actionable to improve behaviours which will improve their health and wellbeing (Chapter Three). Chapters Four, Five, and Six describe the application of this knowledge to design, develop, and recruit participants to a virtual, randomised controlled trial that tested if a digital health intervention for adolescents improved health and wellbeing (Health4Me). An iterative, mixed-methods study design process was used to co-design a bank of text messages that were useful, acceptable, and engaging for adolescents (Chapter Four). Chapter Five presented the randomised controlled trial (RCT) protocol for the Health4Me study. Though the RCT remains ongoing with the final participant follow-up due in October 2024, there are specific learnings already found through the recruitment process and early implementation research with stakeholders to drive further research in this important public health area. Chapter Six examined the recruitment of

participants into the Health4Me RCT through various digital recruitment strategies, and explores factors associated with non-participation. Digital recruitment was found to be low-cost with the potential to increase trial participation, with social media being the most effective. Finally, Australian stakeholders broadly supported digital health prevention programs yet reported that existing initiatives were not fit for purpose. They provided unique insights around the needs of future programs to ensure that they create public health impact and can be implemented (Chapter Seven).

SUMMARY OF KEY FINDINGS

Key findings from this thesis identified that there is a need for digital health interventions to take a holistic focus, adolescent and stakeholder engagement is crucial throughout the entire research process, and digital health literacy and equity must be considered. The key findings are discussed next in the context of the overall thesis.

A need for holistic digital health interventions

Evidence from chapters throughout this thesis demonstrated a need for digital health interventions to take a holistic focus towards improving adolescent health and wellbeing. A holistic focus means to provide support that looks at the whole person across domains of mental, physical, emotional, spiritual, and social wellbeing (1). Results of meta-analyses in Chapter Two found small yet non-significant positive effects of interventions on physical and psychosocial quality of life, depressive symptoms, and anxiety among adolescents. Physical activity and diet were the most targeted health risk behaviours among the included studies. Though non-significant, there was a variety in outcome measures and intervention modes which may have impacted on the overall study findings. In Chapter Four, text messages which scored highly, focused on practical examples, elements other than physical health (e.g. time management, ideas for socialising), and contained links. Adolescent views were

favoured, and 131 text messages formed the text message bank: i) physical activity, ii) nutrition, iii) mental health, iv) body image, v) media, and vi) climate change.

Taking evidence generated in Chapters Two, Three, and Four, an RCT of a co-designed preventive text message intervention (Health4Me) to improve adolescents' physical activity and nutrition outcomes compared to usual care at 6-months was developed and tested for effectiveness among 390 adolescents (12-18 years old). Chapter Five details the published study protocol which incorporates co-primary outcomes of change in proportion of participants meeting vegetable intake guidelines or change in moderate to vigorous physical activity minutes per day. Important secondary outcomes for mental health and wellbeing were also included as identified in Chapter Two (including quality of life, self-efficacy, psychological distress, anxiety, and depressive symptoms). At the time of this thesis submission, the RCT is ongoing, with the final participant follow-up due in October 2024.

Adolescent and stakeholder engagement is crucial throughout the entire research process

It is essential that adolescents are engaged and satisfied with digital health interventions for meaningful changes in key behaviours. In Chapter Two, studies included in the systematic review showed limited reporting of intervention co-design with adolescents. Also, data on intervention satisfaction, engagement, and adherence was poorly reported throughout the included studies. Chapter Three explored adolescents' perceptions on the use of contemporary digital platforms for seeking preventive health information or advice. Adolescents reported that the most helpful information was aesthetically appealing, distributed by a credible and reliable source, and provided information which was both relevant and actionable towards adolescents to improve health behaviours. They also provided mixed views of current online preventive health information being able to positively

change their health behaviours. When adolescents reported that advice was difficult to maintain and incorporate into their daily life, this related to a negative change in their health behaviours.

Using an iterative, mixed-methods study design, the Health4Me text message intervention was co-designed with adolescents, health professionals, and researchers, including a consumer partnership with an established youth advisory group (Chapter Four). The Health Advisory Panel for Youth at the University of Sydney (HAPYUS) are 16 diverse, highly-engaged adolescents (13-18 years old) from New South Wales, Australia, who serve a 12-month term with the research team. In 2021-22, HAPYUS identified the top six health issues for adolescents in relation to chronic disease prevention, which became the key content areas for the Health4Me intervention. Their published perspective detailing these issues is available in Appendix F. Allowing review of the text messages from both adolescents and health professionals uncovered important differences between acceptability and engagement. Importantly, the text message content was useful, acceptable, and engaging to adolescents, evidence-based, and grounded in behaviour change techniques found to be effective in previous systematic reviews. These findings aligned with adolescents' perceptions for preventive information through contemporary digital platforms in Chapter Three.

Finally, given the need to rapidly test and translate adolescent digital health interventions, typical phase-based models of implementation (e.g., applying implementation theories or frameworks to adopt evidence-based practice into usual care after it has demonstrated effectiveness) have the potential to delay their implementation into usual care. Chapter Seven explored stakeholders' perspectives and revealed that existing digital health initiatives were seen as not-for-purpose, and therefore this hindered their widespread implementation.

Success of future digital health prevention programs relies on their co-creation with adolescents, consideration of digital health equity in their development, and addressing larger system-level factors which may affect their implementation. Given the unique and diverse views that stakeholders can bring, engaging them and adolescents throughout the research process is essential to translate digital health prevention programs into health systems and community settings.

Digital health literacy and equity must be considered

This thesis has shown that adolescents are accessing preventive health information across a variety of digital platforms, and it is crucial that digital health literacy and equity are considered in intervention development. In Chapter Two, the included studies used diverse digital health delivery methods including text messaging, mobile applications, websites, email, or a combination of these. In Chapter Three, qualitative data revealed that adolescents search for information both actively through websites (e.g., Google or YouTube) and passively (e.g., social media, mobile applications). The Health4Me intervention (Chapters Four and Five) was delivered via text messages, aiming to be accessible to adolescents across Australia, without the need for an internet connection to receive the intervention. In addition, the average readability score for the intervention was suitable for a seventh grade reading level (12-13 years old). However, the Health4Me study is a virtual clinical trial, meaning there are no physical sites for recruitment, and therefore digital recruitment strategies were examined in detail to understand whether methods were equitable.

Recruitment for the Health4Me study was completed in March 2024, with the target sample size of 390 adolescents reached in just over 12 months. Recruitment materials can all be viewed in Appendix C. Across all recruitment methods, 2369 expressions of interest to take

part in the Health4Me study were received. The total cost per participant enrolled was low (AUD 3.89). The most effective recruitment method was through social media (specifically Meta, which includes Instagram and Facebook), with broad reach and the potential to increase participation, including hard-to-reach populations. However, during the screening phase, statistical analysis demonstrated that there were differences in characteristics between those who did and did not enrol in the study in terms of gender and recruitment method. Regarding gender, fewer people who identified as male and more individuals who reported their gender as 'Other' enrolled in the study than expected than by chance alone. For recruitment method, fewer participants enrolled through Instagram and more enrolled through other methods (e.g., known networks) than expected by chance alone. These results demonstrate the need to explore future digital recruitment strategies which are more effective for people who identify as male and explore issues around trust of health information on social media.

IMPLICATIONS FOR ADVANCING ADOLESCENT HEALTH IN THE DIGITAL ERA

Today's generation of adolescents are the largest generation in history, with 18% of the current Australian population aged 10 to 24 years old (2). With this large and unique population group comes the need to support their health to live long and productive lives and thrive in society in the context of good health and wellbeing (3). Digital technologies are ubiquitous among this population group, allowing the ability to harness them to support and improve adolescent health and wellbeing. This thesis identified specific focus areas that must be considered for digital health prevention interventions to be effective long-term, and implemented into usual care, including the need for meaningful adolescent engagement, shifting the focus to adolescent wellbeing, potential harms of using digital technologies, and progress required to enhance adolescent wellbeing in the digital era.

Meaningful adolescent engagement

The benefits of adolescent engagement in health research are well-documented and can be attributed to the adolescents themselves and the research (4). Benefits to adolescents in HAPYUS have been well documented. The research team conducted a 12-month mixed-methods evaluation of adolescents' participation on their leadership skills and perceptions related to chronic disease prevention research (5). This study found that adolescents within the youth advisory group increased in leadership and life skills scores over 12-months. Furthermore, three key themes related to their participation were identified: influence (power to affect change), empowerment (confidence in skills and knowledge), and contribution (active contributors to health research). A thorough process evaluation established that enablers to adolescent engagement included flexibility, accessible delivery, skill development, and supportive adult facilitators. However, barriers were also identified including time and limited face-to-face components (5). The research team identified key learnings for establishing and facilitating a youth advisory group with the need for flexibility in working style, the importance of redefining power dynamics of working with adolescents, and challenging traditional research structures (Appendix F) (6). HAPYUS was informed by Youth Participatory Action Research Principles (7), which is a process-focused framework for adolescent engagement in research (8). Despite this, through redefining power dynamics throughout the process and challenging research structures, HAPYUS were able to meaningfully engage in chronic disease prevention research with associated impacts (Appendix F) (9, 10).

The evaluation of benefits to the research are ongoing. In Chapter Six, we observe that recruitment resulted in 100% of the sample size for the Health4Me study (n=390) reached in just over 12 months. Recruitment periods of adolescents to prevention clinical trials have been known to take nearly four times as long (11). However, there were differences found in screening characteristics for the recruitment method where less eligible participants enrolled

through Instagram than expected through chance alone. Hypothesised reasons for this include that adolescents are acutely aware of how their personal data is being used and looking for credible and reliable sources of preventive health information (Chapter Two). This will be further explored in the process evaluation for the Health4Me study, by analysing overall retention rates and focus group data from intervention participants.

Despite current guidelines, theories, models, and frameworks on adolescent engagement identified from the literature, they are often narrow in scope and context-specific, leading to a field of research that is still evolving (8, 12). It is also recognised that power imbalances and structural factors can prevent meaningful adolescent participation (13). To enhance meaningful adolescent engagement, there is a need for researchers to conduct rigorous evaluations such as described earlier to advance this field of research. The Lansdown-UNICEF Conceptual Framework provides key outcomes for measuring adolescent participation and is a good starting point to design evaluations of adolescent engagement (14). There is also the need for a shift towards institutional barriers, rather than individual factors, to enhance meaningful adolescent engagement. Adult-centred institutions have a responsibility to share power with adolescents by allowing them to have a voice and platform to share their experiences as adolescents of today. It is only with meaningful adolescent engagement that digital technologies can be co-created to effectively improve adolescent health and wellbeing. In 2021, the WHO published a framework for planning, developing, and implementing digital health solutions with and for young people. This framework provides guidance through both ideas and resources to co-create meaningful adolescent digital health solutions (15). Combining frameworks for adolescent engagement and youth-centred digital health interventions with a rigorous evaluation of their involvement will allow meaningful investment to improve adolescent health outcomes.

Shifting the focus to adolescent wellbeing

Adolescent wellbeing has been gaining significant global attention throughout the course of producing this thesis. Global organisations are calling for urgent investment, with the cost of inaction modelled at USD 4.1 trillion (16). Wellbeing is defined as adolescents have the support, confidence, and resources to thrive in contexts of secure and healthy relationships, realising their full potential and rights (1). The Adolescent Wellbeing Framework proposes five interconnected domains which allow for a holistic perspective: (i) good health and optimum nutrition; (ii) connectedness, positive values, and contribution to society; (iii) safety and a supportive environment; (iv) learning, competence, education, skills, and employability; and (v) agency and resilience (1). Emerging research demonstrates associations between wellbeing and chronic disease outcomes in adulthood, such as cardiovascular disease (17, 18). The importance of wellbeing as a measure of adolescent health has also been reflected in the Adolescent Health Indicators, recommended by the Global Action for Measurement of Adolescent Health (19). However, in Chapter Two, none of the studies measured wellbeing as an outcome. Thus, there lies potential for future digital interventions to focus on enhancing wellbeing as an overall measure of adolescent health.

Chapter Two revealed that potential exists for preventive digital health interventions to improve mental health or wellbeing outcomes among adolescents due to the shared nature of risk and protective factors (e.g., physical activity, optimum nutrition). High-quality emerging evidence supports these findings. A cluster RCT of a school-based lifestyle health behaviour change intervention (Health4Life) among 6,639 Australian adolescents demonstrated short-term benefits of the intervention to improve both psychological distress and depressive symptoms (20). Similarly, longitudinal analysis of the same data revealed health-promoting behaviours are associated with reduced psychological distress and harmful behaviours are associated with increased psychological distress (21). Further evidence from a RCT among 279 Belgian adolescents of the #LIFEGOALS intervention to promote healthy

lifestyles and mental health found mixed results on health behaviours and mental health with beneficial effects on physical activity, sedentary behaviour, sleep quality, and mood (22). The authors highlight the importance of intervention engagement and contextual factors (e.g., COVID-19 measures) which impact upon their findings. Digital tools for mental health promotion have also shown small but promising effects in improving wellbeing outcomes in a recent meta-analysis (23). Thus, these results support the need for a shift to focus on enhancing wellbeing for both mental health and chronic diseases. Future digital interventions should aim to enhance wellbeing across all five domains of the Adolescent Wellbeing Framework (1). However, contemporary influences, including rapid technological changes and a changing policy landscape with regards to social media, are having significant effects on the health and wellbeing of adolescents, making progress to enhance adolescent wellbeing difficult.

Barriers of using digital technologies to enhance adolescent wellbeing

To ensure all adolescents can benefit from digital technologies to support and improve their health and wellbeing, potential harms must be examined and solutions to overcome them identified (24). Within this thesis, it has been demonstrated that social media plays a significant part in adolescents' lives and can be both a positive and negative source of health information. In Chapter Three, adolescents outlined how they passively receive health information through feeds on their social media platforms, either by following people directly or through algorithms which present targeted content to them. In Chapter Four, adolescents identified the impact of social media as one of their top health concerns, which became a key content area for the Health4Me intervention (Chapter Five). In Chapter Six, the evaluation of social media advertisement data to recruit adolescents to the Health4Me study demonstrated that there is potential to increase reach and access to participants who may not otherwise take part in research. Social media can be harmful to adolescent health. A systematic review demonstrated that across four domains of social media (time spent,

activity, investment, and addiction), all correlated with depression, anxiety, and psychological distress (25). However, other research has also demonstrated that the use of social media can be both beneficial and harmful, depending on the levels of use (26). In Australia, current political discourse suggests bipartisan support to raise the age of social media citizenship to 16. This temporary solution would not allow adolescents to learn or manage their exposure to harmful content on social media, which will exist whether adolescents are in this space or not. Different approaches are needed, which aim to optimise benefits and minimise harms to support today's adolescents to navigate social media with appropriate safeguards in place.

Challenges to providing credible and reliable information to adolescents persist as the digital world is highly unregulated. High-quality, accessible services to support and improve health and wellbeing through digital platforms are important to adolescents. This can be seen through global initiatives, such as the 1.8 Billion Young People for Change Campaign (27). However, commercial actors (e.g., big food companies, online health influencers) have capitalised on the vulnerability of adolescents to sell unhealthy products and services via digital platforms and use contemporary marketing strategies which are detrimental to their health and wellbeing (28). Concerningly, there is limited current regulation around marketing and advertising on digital platforms. In 2022, the Australian Therapeutic Goods Administration updated its code to establish restrictions for the advertisement of therapeutic goods including supplements, vitamins, protein powders, and other medical and health-related products (29). Yet, influencer generated weight loss and physique-related content remains popular on Instagram (30). As a result, adolescents are exposed to misinformation, which poses significant threats to health promotion and health equity (31). Adolescents want to be protected in the digital world, but not have their access restricted (32).

Stronger governance around digital platforms is needed to keep adolescents safe in the online world (3). By the time a person reaches their 13th birthday, an estimated 72 million data points on them will have been collected (33). Internet and social media use leaves behind a digital footprint, which can impact both the health and wellbeing of adolescents through targeted advertising, risk of privacy breaches, and affect personal safety and future employability (34). As the use of artificial intelligence (AI) grows among adolescents on platforms such as ChatGPT and Meta AI, these risks are only likely to increase. Advances in AI also creates new opportunities for digital health interventions to deliver personalised preventive health and wellbeing information to adolescents (35). Yet adolescents have concerns around the use of AI tools such as chatbots to deliver such information, due to misinformation and privacy of data collected (Appendix F) (36). Current governance of digital technologies to support adolescent health and wellbeing have fallen behind their innovation and the private sector. Though potential harms have been identified, these can be overcome through multisectoral action.

Progress required to enhance adolescent wellbeing in the digital era

Globally, adolescents are among the highest users of digital technologies (37). The way in which adolescents engage and interact with digital environments depends on their digital health literacy level and their social determinants. To overcome potential harms, adolescents require both education and regulation to keep them safe in digital environments. In addition, the equity of digital health interventions must be considered in their design and development to ensure that digital health interventions do not widen the ‘digital divide’.

Evidence has shown that adolescents require improvement of their digital health literacy to be able to safely and effectively use digital technologies (38). While many studies within the literature make this recommendation, studies which develop education to improve the digital

health literacy of adolescents are limited. A clinical trial among adolescents that aimed to improve digital health literacy reported that education must be made personally relevant to adolescents, to enhance engagement and efficacy (39). While elements of digital literacy are embedded into the Australian curriculum as taught through schooling, the education is not co-designed with adolescents. Co-design may improve the relevance and impact of educational programs, with adolescent views and experiences at the centre of the program. Embedding co-designed educational programs to enhance digital health literacy and measuring this within digital health interventions is essential to equip adolescents with the skills needed to navigate online spaces safely and equitably (40).

Enhancing governance and regulation of digital technologies requires a multisectoral approach. In Australia, the eSafety Commissioner is the independent regulator for online safety, a world-first initiative (41). They also have established a youth council for young people (13-24 years old) to share insights about online safety with eSafety and the government. While this is a progressive measure by the Australian government to keep adolescents safe online, technology companies also have a responsibility to remove misinformation from their platforms and have transparency around what data is collected and where it is stored. The WHO has started the ‘Fides’ initiative to counteract the spread of health-related misinformation and content on social media. While this is a positive step, social media companies also have a responsibility to provide regulation of harmful content and algorithms to protect adolescents online, which has not yet been realised.

To ensure progress with improving adolescent health and wellbeing in the digital age, the equity of digital health interventions must be considered (42). It is important to recognise that the ‘digital divide’ exists, which commonly mirrors socioeconomic divides (43). In Chapter Seven of this thesis, stakeholders recognised that digital health equity must be considered

for successful implementation of digital health prevention programs for adolescents. A recent systematic review demonstrated that most digital health interventions for adolescents do not consider factors that can affect access and engagement and, among those that did, limited strategies were implemented to address these factors when identified (44). However, the equity of digital health interventions goes beyond factors such as access and engagement. The digital determinants of health are a novel construct, which detail how the design, implementation, and use of technology interact with the social determinants of health, considering both elements of health equity and digital health adoption (45). Thus, the digital determinants of health are defined as technological factors that are incorporated to provide affordable, accessible, and quality care, to enhance engagement and experience (45). Future development of digital health prevention interventions must consider the digital determinants of health, to ensure that services are equitable and do not widen existing disparities in healthcare.

FUTURE DIRECTIONS

There is scope to focus future research efforts in developing new or optimising existing adolescent digital health interventions. Through meaningful adolescent and stakeholder engagement, governance to protect adolescents' safety in the digital world and creation of equitable digital health interventions, there is potential to improve adolescent health and wellbeing. Future research must examine whether digital health interventions and programs that target adolescent health and wellbeing are considering the digital determinants of health in their development and design. This consideration is essential to ensure that interventions and programs do not widen the digital divide and will likely be effective in the long-term for improving health and wellbeing of all adolescents. Through systematic reviews of the literature and ongoing evaluation and monitoring of current programs, this research will enable us to understand whether available interventions and programs are equitable and have the capacity to improve the health and wellbeing of all adolescents.

The Health4Me RCT is ongoing with the final participant follow-up in October 2024 and primary and secondary outcomes expected in 2025, along with a complete process evaluation to understand acceptability, utility, and engagement with the intervention. Early implementation work in Chapter Seven provides scope for optimisation of the Health4Me intervention. Optimisation is defined as 'a deliberate, iterative and data-driven process to improve a health intervention or its implementation to meet stakeholder-defined public health impacts within resource constraints' and had the potential to improve intervention impact (46). Further research combining efficacy and process evaluation data will aim to enhance the Health4Me intervention design, delivery, and equity, in collaboration with adolescents. While engaging adolescents meaningfully throughout the entire research progress is crucial, other key stakeholders (e.g., adults, institutions, and governments) must also take responsibility to ensure adolescent voices are upheld, in line with their rights. Therefore, it is essential to understand what existing digital preventive health interventions are available for adolescents across Australia, and how a co-designed intervention such as Health4Me could be effectively implemented into healthcare or community settings. Given the complexity of the Australian health system, which operates across different jurisdictions, a systems-thinking approach would be beneficial (47). This would require working with stakeholders and adolescents to co-design implementation strategies to deliver digital preventive interventions which benefit adolescents now and into the future.

STRENGTHS AND LIMITATIONS

This thesis provides comprehensive and thorough evidence across six results chapters to advance adolescent health promotion in the digital era. There are several identified strengths. Qualitative study designs captured views of both adolescents (Chapters Three and Four) and stakeholders (Chapter Seven) regarding the design and implementation of digital health prevention interventions. The rigor in these qualitative and mixed-methods

studies limits potential bias, with best-practice methods and reporting used throughout. In addition, these chapters provide rich insights into adolescents' and stakeholders' views and experiences that would not otherwise be found in the literature. High-quality quantitative studies (Chapters Two and Six) provide reliable and statistically valid results. Where statistical tests were used, methods and outcomes were discussed with statisticians to ensure that tests were applied correctly, and interpretation was correct. The findings from Chapters Two, Three, and Four have already been practically applied to form the Health4Me digital intervention (RCT protocol presented in Chapter Five). In addition, all studies within this thesis were designed with consideration to the most current strategies and guidelines from the Australian government. For example, the research aligns with the National Action Plan for the Health of Children and Young People and the National Preventive Health Strategy. Outcomes from the Health4Me intervention are also aligned with the Australian Physical Activity and Dietary Guidelines. Aligning the research with national strategies and guidelines enhances the relevance of the research and will support future implementation.

Each chapter of this thesis provides a thorough discussion of the findings in the context of the most up-to-date literature at the time each study was published. However, digital health is a rapidly evolving field and while peer-reviewed publications within this thesis referenced up-to-date literature at the time of publication, some references are now out of date. Additionally, policy and advertising changes on social media platforms are rapidly updated and therefore some of these may have been updated over the course of producing this thesis. Every effort has been made to reference the most up-to-date literature in unpublished chapters. In addition, this thesis had further limitations in relation to generalisability, measurement, and digital health literacy.

Apart from Chapter Two, all studies within this thesis were undertaken in Australia. Even in Chapter Two, most of the studies included were conducted in high-income countries. Thus, the results of this thesis are predominantly limited to the Australian context but may have applicability to other high-income countries. Emerging research has suggested key aspects to consider in the development of adolescent digital health promotion tools in LMICs including: (i) addressing the digital divide; (ii) engaging the target population to respond to their specific needs given economic, cultural, and social contexts; (iii) monitoring the quality and impact of digital tools over time; and (iv) improving technology governance (48). Many of these findings from LMICs are similar to the findings within this thesis. Chapter Four successfully engaged adolescents to co-design a digital health prevention intervention. Chapter Seven saw stakeholders recognise the need to address digital health equity for successful implementation of adolescent digital health prevention programs, and the need for system-level factors to be addressed, including monitoring and evaluation of digital tools. Given the findings of this thesis are similar to published studies from LMICs, there is potential that this work may be applicable to other contexts if adolescents are meaningfully engaged throughout the process.

Historically, there has been a lack of comprehensive indicators to measure adolescent health outcomes. This has been a critical gap for advancing adolescent health agendas globally (49, 50). This finding was mirrored within this body of work. In Chapter Two it was noted that there were a variety of outcome indicators used to measure mental health and wellbeing outcomes and was an identified limitation due to the variation in measurements. The findings from this work were used to inform outcomes collected in the Health4Me RCT (Chapter Five). Considerable progress has been made in this space with the recent launch of the adolescent health indicators, which give global guidance to improve measurement of adolescent health. The indicators span a range of adolescent health issues including physical health, mental health, sexual and reproductive health, and social wellbeing (19).

Future use of these indicators will assist with driving the global agenda to improve the health and wellbeing of adolescents now and in the future.

Chapters Three, Four, Five, and Six all recruited and took place in the digital environment, and thus it must be acknowledged that individuals with lower digital health literacy skills may not be represented within this body of work. Chapter Three, Four, and Five all recruited via social media. Focus groups from Chapter Three took place on Zoom teleconference, Chapter Four used an online survey, and Chapter Five used online surveys for data collection and the Health4Me intervention was delivered via text messaging. eHealth literacy status was measured as part of the Health4Me RCT (Chapter Five), and this outcome will be available once the study is completed. Chapter Six aimed to evaluate factors associated with non-participation in the Health4Me RCT from various digital recruitment strategies and did uncover that recruitment method was significant with fewer participants enrolling through Instagram and more enrolling through other methods (e.g., known networks) than expected by chance alone. Regardless, there is a need to enhance the digital health literacy skills of all adolescents through co-designed educational programs (40) for digital health prevention programs to be successful long-term.

CONCLUSIONS

Adolescents today remain at risk of developing non-communicable diseases in the future unless there is dedicated investment in them as a unique population group. To progress, meaningfully engaging with adolescents to develop solutions to improve health and wellbeing which meet their needs are required. Whilst adolescent health is gaining attention, for example through the Global Forum for Adolescents, urgent accessible solutions are needed. Overall, this thesis provides evidence to support the use of digital health interventions to improve adolescent health and wellbeing by targeting protective factors such

as nutrition and physical activity. It also provides evidence from both adolescent and stakeholder perspectives to ensure that digital health prevention information can be successfully implemented. Future research is needed to analyse outcomes from the Health4Me RCT and conduct a thorough process evaluation to understand the acceptability, utility, and engagement with the intervention. Combining these with the findings from this thesis will define priorities for intervention optimisation and a future implementation trial with long-term follow-up.

REFERENCES

1. Ross DA, Hinton R, Melles-Brewer M, Engel D, Zeck W, Fagan L, et al. Adolescent well-being: A definition and conceptual framework. J Adolesc Health. 2020;67(4):472-476.

2. Australian Bureau of Statistics. Snapshot of Australia: ABS [Internet]. 2021. cited 2024 Jul 2]. Available from: https://www.abs.gov.au/statistics/people/people-and-communities/snapshot-australia/2021#cite-window1

3. Patton GC, Sawyer SM, Santelli JS, Ross DA, Afifi R, Allen NB, et al. Our future: A Lancet commission on adolescent health and wellbeing. Lancet. 2016;387(10036):2423-2478.

4. Wilson O, Daxenberger L, Dieudonne L, Eustace J, Hanard A, Krishnamurthi A, et al. A rapid evidence review of young people's involvement in health research. London: Wellcome; 2020. Available from: https://cms.wellcome.org/sites/default/files/2021-02/a-rapid-evidence-review-of-young-peoples-involvement-in-health-research.pdf

5. Mandoh M, Raeside R, Todd A, Redfern J, Mihrshahi S, Cheng HL, et al. Evaluating the effect of a 12-month youth advisory group on adolescent's leadership skills and perceptions related to chronic disease prevention research: A mixed-methods study. BMC Public Health. 2023;23(1):2344.

6. Partridge SR, Mandoh M, Todd A, Raeside R. Engaging adolescents in chronic disease prevention research: Insights from researchers about establishing and facilitating a youth advisory group. Res Involv Engagem. 2024;10(1):29.

7. Ozer EJ. Youth-led participatory action research: Overview and potential for enhancing adolescent development. Child Dev Persp. 2017;11(3):173-177.

8. Sanchez S, Thorburn R, Rea M, Kaufman P, Schwartz R, Selby P, et al. A systematic review of theories, models and frameworks used for youth engagement in health research. Health Expect. 2024;27(1):e13975. doi: 10.1111/hex.13975

9. Valanju R, Barani M, Mautner D, Al Hadaya I, Cross A, Gunawardana M, et al. Youth perspective on chronic disease prevention. Lancet Child Adolesc Health. 2022;6(7):456-458.

10. Mautner D, Valanju R, Al Hadaya I, Barani M, Cross A, McMahon E, et al. Experiences from youth advisors in chronic disease prevention research. Res Involv Engagem. 2024;10(1):56.

11. Kilicel D, De Crescenzo F, Pontrelli G, Armando M. Participant recruitment issues in child and adolescent psychiatry clinical trials with a focus on prevention programs: A meta-analytic review of the literature. J Clin Med. 2023;12(6):2307.

12. Warraitch A, Wacker C, Bruce D, Bourke A, Hadfield K. A rapid review of guidelines on the involvement of adolescents in health research. Health Expect. 2024;27(3):e14058.

13. Kapeke K, Muse K, Rowan J, Saw P, White T, Ojinnaka-Psillakis A, et al. Who holds power in decision making for young people's future? Med J Aust. 2023;219(S10):S30-S34.

14. UNICEF. Conceptual framework for measuring outcomes of adolescent participation. New York, USA; 2018. Available from: https://www.unicef.org/media/59006/file

15. World Health Organization. Youth-centred digital health interventions: A framework for planning, developing and implementing solutions with and for young people. Geneva; 2020. Available from: https://iris.who.int/bitstream/handle/10665/336223/9789240011717-eng.pdf?sequence=1

16. World Health Organization. Adolescents in a changing world: The case for urgent investment. Geneva; 2024. Available from: https://www.unfpa.org/sites/default/files/pub-pdf/adolescents-in-a-changing-world---the-case-for-urgent-invesment.pdf

17. Qureshi F, Guimond A-J, Delaney S, Boehm JK, Kubzansky LD. Who benefits and how: Five dimensions of adolescent psychological well-being and their relative impact on cardiometabolic health in adulthood. J Adolesc Health. 2024;75(1):85-93.

18. Qureshi F, Guimond AJ, Tsao E, Delaney S, Boehm JK, Kubzansky LD. Adolescent psychological assets and cardiometabolic health maintenance in adulthood: Implications for health equity. J Am Heart Assoc. 2023;12(2):e026173.

19. United Nations Population Fund. The adolescent health indicators. 2024. Available from: https://www.unfpa.org/sites/default/files/pub-pdf/WHO_AYH_GAMA_Indicators.pdf

20. Smout S, Champion KE, O'Dean S, Teesson M, Gardner LA, Newton NC. Anxiety, depression and distress outcomes from the Health4Life intervention for adolescent mental health: A cluster-randomized controlled trial. Nature Mental Health. 2024;2:818-827.

21. Smout S, Champion KE, O'Dean S, Halladay J, Gardner LA, Newton NC. Adolescent lifestyle behaviour modification and mental health: Longitudinal changes in diet, physical activity, sleep, screen time, smoking, and alcohol use and associations with psychological distress. Int J Mental Health Addict. 2024. doi: 10.1007/s11469-024-01350-9

22. Peuters C, Maenhout L, Cardon G, De Paepe A, DeSmet A, Lauwerier E, et al. A mobile healthy lifestyle intervention to promote mental health in adolescence: A mixed-methods evaluation. BMC Public Health. 2024;24(1):44.

23. Wright M, Reitegger F, Cela H, Papst A, Gasteiger-Klicpera B. Interventions with digital tools for mental health promotion among 11–18 year olds: A systematic review and meta-analysis. J Youth Adolesc. 2023;52(4):754-779.

24. Holly L, Wong BLH, Agrawal A, Awah I, Azelmat M, Kickbusch I, et al. Opportunities and threats for adolescent well-being provided by digital transformations. 2021. Available from: https://pmnch.who.int/resources/publications/m/item/opportunities-and-threats-for-adolescent-well-being-provided-by-digital-transformations

25. Keles B, McCrae N, Grealish A. A systematic review: the influence of social media on depression, anxiety and psychological distress in adolescents. Int J Adolesc Youth. 2020;25(1):79-93.

26. Keum BT, Wang Y-W, Callaway J, Abebe I, Cruz T, O'Connor S. Benefits and harms of social media use: A latent profile analysis of emerging adults. Curr Psychol. 2023;42(27):23506-18.

27. PMNCH. Agenda for action for adolescents. 2023. Available from: https://www.1point8b.org/agendaforactionforadolescents

28. Pitt H, McCarthy S, Arnot G. Children, young people and the commercial determinants of health. Health Promot Int. 2024;39(1):daad185.

29. Australian Government Department of Health and Aged Care. TGA social media advertising guide. 2022. Available from: https://www.tga.gov.au/resources/resource/guidance/tga-social-media-advertising-guide

30. Denniss E, Lindberg R, McNaughton SA. Nutrition-related information on Instagram: A content analysis of posts by popular Australian accounts. Nutrients. 2023;15(10):2332.

31. Wang ML, Togher K. Health misinformation on social media and adolescent health. JAMA Pediatr. 2024;178(2):109-110.

32. United Nations Convention on the Rights of the Child. General comment No. 25 (2021) on children's rights in relation to the digital environment. 2021. Available from: https://www.ohchr.org/en/documents/general-comments-and-recommendations/general-comment-no-25-2021-childrens-rights-relation

33. Videoweek. Ad tech collects 72 million data points on the average American child by age 13. 2017. Available from: https://videoweek.com/2017/12/14/ad-tech-collects-72-million-data-points-on-the-average-american-child-by-age-13/

34. Buchanan R, Southgate E, Smith SP, Murray T, Noble B. Post no photos, leave no trace: Children's digital footprint management strategies. E-Learning and Digital Media. 2017;14(5):275-290.

35. Rowe JP, Lester JC. Artificial intelligence for personalized preventive adolescent healthcare. J Adolesc Health. 2020;67(2, Supplement):S52-S58.

36. Han R, Todd A, Wardak S, Partridge SR, Raeside R. Feasibility and acceptability of chatbots for nutrition and physical activity health promotion among adolescents: Systematic scoping review with adolescent consultation. JMIR Hum Factors. 2023;10:e43227.

37. Benvenuti M, Wright M, Naslund J, Miers AC. How technology use is changing adolescents' behaviors and their social, physical, and cognitive development. Curr Psychol. 2023;42(19):16466-9.

38. Taba M, Allen TB, Caldwell PHY, Skinner SR, Kang M, McCaffery K, et al. Adolescents' self-efficacy and digital health literacy: A cross-sectional mixed methods study. BMC Public Health. 2022;22(1):1223.

39. Paek H-J, Hove T. Social cognitive factors and perceived social influences that improve adolescent eHealth literacy. Health Communic. 2012;27(8):727-737.

40. Lewis CC, Taba M, Allen TB, Caldwell PH, Skinner SR, Kang M, et al. Developing an educational resource aimed at improving adolescent digital health literacy: Using co-design as research methodology. J Med Internet Res. 2024;26:e49453.

41. Australian Government. eSafety Commissioner. [Internet]. 2024. cited 2024 Aug 21]. Available from: https://www.esafety.gov.au/

42. Richardson S, Lawrence K, Schoenthaler AM, Mann D. A framework for digital health equity. NPJ Digit Med. 2022;5(1):119.

43. Hanebutt R, Mohyuddin H. The digital domain: A ‘super’ social determinant of health. Primary Care: Clinics in Office Practice. 2023;50(4):657-670.

44. Whitehead L, Robinson S, Arabiat D, Jenkins M, Morelius E. The report of access and engagement with digital health interventions among children and young people: A systematic review. JMIR Pediatr Parent. 2024;7:e44199.

45. Chidambaram S, Jain B, Jain U, Mwavu R, Baru R, Thomas B, et al. An introduction to digital determinants of health. PLOS Digit Health. 2024;3(1):e0000346.

46. McCrabb S, Mooney K, Elton B, Grady A, Yoong SL, Wolfenden L. How to optimise public health interventions: A scoping review of guidance from optimisation process frameworks. BMC Public Health. 2020;20(1):1849.

47. Haynes A, Rychetnik L, Finegood D, Irving M, Freebairn L, Hawe P. Applying systems thinking to knowledge mobilisation in public health. Health Res Policy Syst. 2020;18(1):134.

48. Ferretti A, Vayena E, Blasimme A. Unlock digital health promotion in LMICs to benefit the youth. PLOS Digit Health. 2023;2(8):e0000315.

49. Guthold R, Moller A-B, Adebayo E, Carvajal L, Ekman C, Fagan L, et al. Priority areas for adolescent health measurement. J Adolesc Health. 2021;68(5):888-898.

50. Guthold R, Moller AB, Azzopardi P, Ba MG, Fagan L, Baltag V, et al. The Global Action for Measurement of Adolescent health (GAMA) initiative: Rethinking adolescent metrics. J Adolesc Health. 2019;64(6):697-699.

APPENDICIES

Appendix A – Good Clinical Practice and Motivational Interviewing Certificates

ARCS Australia Ltd provides this Certificate of Attendance to

Rebecca Raeside

In recognition of successful participation in:

Refresher GCP training for clinical investigational sites E6(R2) Jul 2020 (2)

Facilitator: Sue Mason

CPD Earned: 2

Date Issued:30 Jul 2020

This ICH E6 GCP Investigator Site Training meets the Minimum Criteria for ICH GCP Investigator Site Personnel Training identified by TransCelerate BioPharma as necessary to enable mutual recognition of GCP training among trial sponsors

[redacted]

Joseph Badolato PhD Director Education
ARCS Australia

THE GLOBAL HEALTH NETWORK

Enabling research by sharing knowledge

Hereby Certifies that

REBECCA RAESIDE

has completed the e-learning course

ICH GOOD CLINICAL PRACTICE E6 (R2)

with a score of

89%

on

17/07/2023

This e-learning course has been formally recognised for its quality and content by the following organisations and institutions

*This ICH E6 GCP Investigator Site Training meets the Minimum Criteria for ICH GCP Investigator Site Personnel Training identified by **TransCelerate BioPharma** as necessary to enable mutual recognition of GCP training among trial sponsors.*

ALERRT REDe Research Capacity Network Global Research Nurses THE GLOBAL HEALTH NETWORK

Global Health Training Centre
globalhealthtrainingcentre.org/elearning

[redacted]

CERTIFICATE OF ACHIEVEMENT

THIS IS TO CERTIFY THAT

Rebecca Raeside

SUCCESSFULLY COMPLETED

Introduction to Motivational Interviewing

[redacted]

NSW GOVERNMENT Health

ISSUED 11th January 2023

[redacted]

ANNETTE SOLMAN
CHIEF EXECUTIVE

HETI
HEALTH EDUCATION & TRAINING INSTITUTE

CERTIFICATE OF ACHIEVEMENT

THIS IS TO CERTIFY THAT

Rebecca Raeside

SUCCESSFULLY COMPLETED

Motivational Interviewing: Building Skills

[redacted]

NSW GOVERNMENT Health

ISSUED 11th January 2023

[redacted]

ANNETTE SOLMAN
CHIEF EXECUTIVE

HETI
HEALTH EDUCATION & TRAINING INSTITUTE

Appendix B – DIGITALIZE Study Ethics Approvals and Participant Information and Consent Forms

THE UNIVERSITY OF SYDNEY

Research Integrity & Ethics Administration
HUMAN RESEARCH ETHICS COMMITTEE

Wednesday, 30 September 2020

Dr Stephanie Partridge
Westmead Clinical School: Medicine; Faculty of Medicine and Health
Email: stephanie.partridge@sydney.edu.au

Dear Stephanie,

The University of Sydney Human Research Ethics Committee (HREC) has considered your application.

I am pleased to inform you that after consideration of your response, your project has been approved.

Details of the approval are as follows:

Project No.:	**2020/613**
Project Title:	**Digital sources of lifestyle health information for adolescents living in the generation z era: Study protocol for a cross-sectional online survey**
Authorised Personnel:	**Partridge Stephanie; Armstrong Matthew; Halim Nicole; Jia Si; Mandoh Mariam; Phongsavan Philayrath; Raeside Rebecca; Redfern Julie;**
Approval Period:	**30 September 2020** to **30 September 2024**
First Annual Report Due:	**30 September 2021**

Documents Approved:

Date Uploaded	Version Number	Document Name
23/09/2020	Version 3	PIS clean
11/09/2020	Version 2	Consent form clean
11/09/2020	Version 2	Protocol clean
11/09/2020	Version 2	Advertising clean
11/09/2020	Version 2	Main survey
11/09/2020	Version 2	Participant details survey

Condition/s of Approval

- Research must be conducted according to the approved proposal.
- An annual progress report must be submitted to the Ethics Office on or before the anniversary of approval and on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:
  - Serious or unexpected adverse events (which should be reported within 72 hours).
  - Unforeseen events that might affect continued ethical acceptability of the project.
- Any changes to the proposal must be approved prior to their implementation (except where an amendment is undertaken to eliminate *immediate* risk to participants).
- Personnel working on this project must be sufficiently qualified by education, training and experience for their role, or adequately supervised. Changes to personnel must be reported and approved.
- Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, as relevant to this project.

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Research Portfolio
Level 3, F23 Administration Building
The University of Sydney
NSW 2006 Australia

T +61 2 9036 9161
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ABN 15 211 513 464
CRICOS 00026A

THE UNIVERSITY OF SYDNEY

- Data and primary materials must be retained and stored in accordance with the relevant legislation and University guidelines.
- Ethics approval is dependent upon ongoing compliance of the research with the *National Statement on Ethical Conduct in Human Research*, the *Australian Code for the Responsible Conduct of Research*, applicable legal requirements, and with University policies, procedures and governance requirements.
- The Ethics Office may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

This letter constitutes ethical approval only.

Please contact the Ethics Office should you require further information or clarification.

Sincerely

[redacted]

Associate Professor Helen Mitchell
Chair
Human Research Ethics Committee (HREC 1)

The University of Sydney of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2018) and the NHMRC's Australian Code for the Responsible Conduct of Research (2018)

THE UNIVERSITY OF SYDNEY

Research Integrity & Ethics Administration
HUMAN RESEARCH ETHICS COMMITTEE

Monday, 5 July 2021

Dr Stephanie Partridge
Westmead Clinical School: Medicine; Faculty of Medicine and Health
Email: stephanie.partridge@sydney.edu.au

Dear Stephanie,

Your request to modify this project, which was submitted on 15 June 2021, has been considered.

After consideration of your response to the comments raised, this project has been approved to proceed with the proposed amendments.

Protocol Number: **2020/613**

Protocol Title: **Digital sources of lifestyle health information for adolescents living in the generation z era: Study protocol for a cross-sectional online survey and qualitative study**

Annual Report Due: **30 September 2021**

Documents Approved:

Date Uploaded	Version Number	Document Name
28/06/2021	Version 2	DIGITALIZE Study Protocol Version 2 28 June 2021_CLEAN
28/06/2021	Version 2	DIGITALIZE Study Focus Group Discussion Guide CLEAN
15/06/2021	Version 1	DIGITALIZE Study Consent form Phase 2
15/06/2021	Version 1	DIGITALIZE Study Participant Demographics Survey
15/06/2021	Version 1	DIGITALIZE Study Participant Information Sheet Phase 2
15/06/2021	Version 1	DIGITALZE Study - Recruitment Advertising Phase 2

Please contact the ethics office should you require further information.

Sincerely,

[redacted]

Associate Professor Stephen Fuller
Chair
Modification Review Committee Chair (MRC 1)

The University of Sydney of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2018) and the NHMRC's Australian Code for the Responsible Conduct of Research (2018)

THE UNIVERSITY OF SYDNEY

Westmead Applied Research Centre
Faculty of Medicine and Health

ABN 15 211 513 464

Dr Stephanie Partridge
NHMRC/National Heart Foundation Research Fellow

Acacia House
Westmead Hospital
The University of Sydney
NSW 2145 AUSTRALIA
Telephone: +61 2 8890 8187
Email: stephanie.partridge@sydney.edu.au
Web: http://www.sydney.edu.au/

Participant Information Sheet - The DIGITALIZE Study Phase 2

Who is running the study?

This survey is being conducted by researchers from The University of Sydney. Our names are Stephanie Partridge, Nicole Halim, Julie Redfern, Philayrath Phongsavan, Matthew Armstrong, Rebecca Raeside, Mariam Mandoh, Sisi Jia and Karice Hyun.

Nicole Halim designed the survey as the basis of the degree of Master of Public Health at The University of Sydney and Matt Armstrong is conducting this study as the basis for the degree of Honours of Applied Medical Science at The University of Sydney. Both will take place under the supervision of Dr Stephanie Partridge.

What is this study about?

We want to hear from young people about their thoughts and experiences with getting digital health information. We are doing a focus group, as a follow-up to the survey to find out more about how young people, **13-18 years old** search for lifestyle health-related information online. The focus group includes questions about your digital health information seeking behaviours on social media, apps, websites and streaming services.

Who can take part in the study?

To participate in this survey, you need to:

- Be aged between 13 and 18 years old
- Live in Australia
- Have searched for online health information at least once per month in the last 3 months;

The focus group will take about 45 minutes to complete. It asks you about your opinions on the digital platforms that you use to access lifestyle health-related information online. Your responses will remain strictly confidential within the focus group and you will be de-identified in any published findings.

At the end of the focus group, you will receive a Gift Voucher, valued at $20.

If you have any questions, please contact Stephanie from the research team at stephanie.partridge@sydney.edu.au.

The University of Sydney Ethics Approval Number: 2020/613.

Would you like to see additional details about the study?

- ○ **Yes**
- ○ **No**

Additional Information: The DIGITALIZE Study

This additional information tells you what we will ask you to do if you decide to join the study. Knowing what is involved will help you decide if you want to take part in the research. Please read it carefully so that you can make up your mind about whether you want to take part.

Do I have to be in the study? Can I withdraw from the study once I've started?

The focus group is completely voluntary. You can decide if you want to take part in it or not. Participation is completely up to you. You can stop at any time without giving a reason.

If you withdraw from the focus group after it has started, any contribution to the discussion prior to withdrawal will not be able to be removed from the recording and/or written transcript.

What will the study involve for me?

If you decide that you want to be in our study, we will ask you to do these things:

- Complete one online 45-minute focus group via Zoom (Zoom Video Communications, Inc) about how, where and why you search for lifestyle health-related information online

When we ask you questions, you can choose to contribute to the group discussion. If you don't want to contribute or feel that you don't have anything else to express, that's okay.

What will happen to information about me that is collected during the study?

By providing your consent, you are agreeing to us collecting personal information about you for the purposes of this research study. Your information will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise.

The focus group will involve a brief introduction of the group participants at the beginning. All responses and discussion in the focus group will be kept confidential within the group. We will only request your contact details at the end if you want to:

- Receive your gift voucher
- Want to know about the study results once it is finished
- Be willing to be contacted for future research

However, these details are kept separate from the focus group and will not be linked in any way to the answers you provide.

All the information you provide to us during the study will be kept confidential and stored securely and your identity/information will be kept strictly confidential. We will write a report about the study, which may be published later and key findings from the report shared on social media. However, we will not mention your name anywhere in the report or key findings on social media, and no one will know that you took part in the study

How long will the study take?

The focus group will take about 45 minutes to complete.

Are there any benefits associated with being in the study?

By participating in the study, you will be helping us do our research which focuses on adolescent health. There are no direct benefits from participating in the survey. However, by taking the survey you will be reimbursed for their time with a $20 Gift Voucher for The Iconic or JB Hi-Fi.

Are there any risks or costs associated with being in the study?

This study will take up some of your time, we do not expect that there will be any risks or costs associated with taking part in this study. Questions relating to lifestyle behaviours and social media may be sensitive to some young people. If any of these questions make you feel distressed or upset, we recommend that you stop the focus group at any time. We will open up a private break-out room on Zoom with a member of the research team and we will recommend you first contact your General Practitioner. Here are other contacts you can talk to and websites you can access if you feel distressed or upset, if that is what you want to do.

Kids Helpline:	T: 1800 551 800	W: kidshelpline.com.au
The Butterfly Foundation:	T: 1800 334 673	W: thebutterflyfoundation.org.au
ReachOut:		W: au.reachout.com
HeadSpace:		W: headspace.org.au

Can I tell other people about the study?

Yes, you are welcome to tell other people about the study.

What if I have any questions or would like further information about the study?

If you have any questions about the study, you can ask us or your family or someone else who looks after you. If you want to, you can call Stephanie Partridge on +61 2 8890 8187.

Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. You can tell us that you wish to receive feedback by at the end of the survey, which asks you if you would like to receive a summary of the study results. If you answer ‘Yes’, when we finish the study, we will tell you what we learnt by emailing you a one-page summary. If you select ‘Yes’, you will receive this feedback after the study is finished.

What if I have a complaint or any concerns about the study?

Research involving humans in Australia is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this study have been approved by the HREC of the University of Sydney 2020/613. As part of this process, we have agreed to carry out the study according to the National Statement on Ethical Conduct in Human Research (2007). This statement has been developed to protect people who agree to take part in research studies.

If you are not happy with how we are doing the study or have any complaints about the way the study is conducted, then you or the person who looks after you can contact the university using the details outlined below. Please tell them the study title and protocol number.

- **Call** the university on +61 2 8627 8176 or
- Write an **email** to human.ethics@sydney.edu.au
-

THE UNIVERSITY OF SYDNEY

Westmead Applied Research Centre
Faculty of Medicine and Health

ABN 15 211 513 464

Dr Stephanie Partridge
NHMRC/National Heart Foundation Research Fellow

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NSW 2145 AUSTRALIA
Telephone: +61 2 8890 8187
Email:
stephanie.partridge@sydney.edu.au
Web: http://www.sydney.edu.au/

Participant Consent Form - The DIGITALIZE Study Phase 2

You should only consent to being in the study once you have read and understood what the study is about, and you want to be in it. If you do not want to participate in our study, select "no" in the form below.

In giving my consent I state that:

- I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.
- I have read the Participant Information Sheet and my questions have been answered by either the Participant Information Sheet, my parent/guardian or the researchers and I am happy with the answers.
- I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of Sydney now or in the future.
- I understand that I can withdraw from the study at any time by stopping the online focus group.
- I understand that my responses cannot be withdrawn once the focus group has started, as they are anonymous and therefore the researchers will not be able to tell which one is mine.
- I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to.
- I understand that the results of this study may be published, and that publications will not contain my name or any identifiable information about me.
- I am providing consent

    - Yes
    - No

Appendix C – Health4Me Study Ethics Approvals, Participant Information and Consent Forms and Recruitment Materials

THE UNIVERSITY OF SYDNEY

Research Integrity & Ethics Administration
HUMAN RESEARCH ETHICS COMMITTEE

Thursday, 30 June 2022

Dr Stephanie Partridge
Health Sciences; Faculty of Medicine and Health
Email: stephanie.partridge@sydney.edu.au

Dear Stephanie,

The University of Sydney Human Research Ethics Committee (HREC) has considered your application.

After consideration of your response to the comments raised your project has been approved.

If your research project is a clinical trial and is being sponsored by the University or is to be conducted on a University of Sydney site, you must comply with additional University governance requirements prior to commencing your Clinical Trial.

Protocol Number:	**2022/402**
Protocol Title:	**Health4Me: A community-based text message intervention to improve adolescent physical and mental health outcomes via primary care**
Authorised Persons:	**Partridge Stephanie; Figtree Gemma Alexandra; Gallagher Robyn; Hackett Maree; Hyun Karice; Kang Melissa; Raeside Rebecca; Redfern Julie; Steinbeck Katharine (Kate); Mihrshahi Seema;**
Approval Period:	**30/06/2022** to **30/06/2026**
First Annual Report Due:	**30/06/2023**

Documents Approved:

Date Uploaded	Version Number	Document Name
23/06/2022	Version 1	HEALTH4ME_RCT Phase 2 PICF Young Person_V1 23062022_CLEAN
23/06/2022	Version 1	HEALTH4ME_RCT Phase 2 PICF Parent Guardian_V1 23062022_CLEAN
23/06/2022		REDCap_Phase 1_DemographicsPro_HEALTH4METextMess
23/06/2022		REDCap_Phase 2_Demographics_HEALTH4MERCT
23/06/2022		Standard Operating Procedure_Assessing Weight Status
23/06/2022		REDCap_Phase 1_Demographics_HEALTH4METextMess
22/04/2022		Phase 2 - Anxiety Questionnaire
22/04/2022		Phase 2 - Physical Activity
22/04/2022		Phase 2 - Demographics Survey
22/04/2022		Phase 2 - Form 4 6-Month Follow-Up
22/04/2022	Version 1	Phase 3 - Focus Group Discussion Guide
22/04/2022		Phase 2 - Food Insecurity Questionnaire
22/04/2022		Phase 2 - Eating Disorder Screening
22/04/2022		Phase 2 - Psychological Distress Questionnaire
22/04/2022		Phase 2 - Depression Questionnaire
22/04/2022		Phase 2 - Self-efficacy Questionnaire
22/04/2022		Phase 2 - Australian Eating Survey
22/04/2022		Phase 2 - Form 5 Process Evaluation
22/04/2022		Phase 2 - Form 3 Baseline
22/04/2022		Phase 2 - Form 2 Contact Details
22/04/2022		Phase 2 - Form 1 Screening
22/04/2022	Version 1	Phase 2 Referral Letter - Eating Disorder

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The University of Sydney
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CRICOS 00026A

22/04/2022		Phase 2 - Social Media Advertising Images
22/04/2022	Version 1	Phase 2 - Social Media Advertising
22/04/2022	Version 1	Phase 1 PICF - Young Person
22/04/2022	Version 1	Phase 1 PICF - Parent Guardian
22/04/2022	Version 1	Phase 1 PICF - Experts
22/04/2022	Version 1	Health4Me Protocol
22/04/2022		Phase 1 - Text Message Review Survey
22/04/2022		Phase 2 - Sleep Quality Questionnaire
22/04/2022		Phase 2 - Eating Disorder Questionnaire
22/04/2022		Phase 2 - eHealth Literacy Questionnaire
22/04/2022		Phase 1 - Demographics Survey
22/04/2022		Phase 2 - Quality of Life Questionnaire

Special Conditions of Approval for Clinical Trials

- **This letter constitutes ethical approval only.** This project cannot proceed at any site until the necessary research governance authorisation is obtained. If your study is sponsored by the University or is to be conducted on a University of Sydney site you may need to comply with additional University governance requirements prior to commencing. Please contact the Clinical Trials Governance Office at clinical-trials.research@sydney.edu.au
- Clinical Trials must be registered on a clinical trials registry that complies with the International Committee of Medical Journal Editors (ICMJE). For trials conducted in Australia or New Zealand registration should be on the Australian New Zealand Clinical Trial Registry before recruitment of the first subject (http://www.anzctr.org.au/).

Condition/s of Approval

- Research must be conducted according to the approved proposal.
- An annual progress report must be submitted to the Ethics Office on or before the anniversary of approval and on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:
  - Serious or unexpected adverse events (which should be reported within 72 hours).
  - Unforeseen events that might affect continued ethical acceptability of the project.
- Any changes to the proposal must be approved prior to their implementation (except where an amendment is undertaken to eliminate *immediate* risk to participants).
- Personnel working on this project must be sufficiently qualified by education, training and experience for their role, or adequately supervised. Changes to personnel must be reported and approved.
- Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, as relevant to this project.
- Data and primary materials must be retained and stored in accordance with the relevant legislation and University guidelines.
- Ethics approval is dependent upon ongoing compliance of the research with the *National Statement on Ethical Conduct in Human Research*, the *Australian Code for the Responsible Conduct of Research*, applicable legal requirements, and with University policies, procedures and governance requirements.

- The Ethics Office may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

Please contact the Ethics Office should you require further information or clarification.

Sincerely,

[redacted]

Dr Kathryn Bartimote
Deputy Chair
Human Research Ethics Committee (HREC 2)

cc. Clinical Trial Governance

The University of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2018) and the NHMRC's Australian Code for the Responsible Conduct of Research (2018).

THE UNIVERSITY OF SYDNEY

Research Integrity & Ethics Administration
HUMAN RESEARCH ETHICS COMMITTEE

Friday, 23 September 2022

Dr Stephanie Partridge
Health Sciences; Faculty of Medicine and Health
Email: stephanie.partridge@sydney.edu.au

Dear Stephanie,

Your request to modify this project, which was submitted on 23/08/2022, has been considered.

After consideration of your response to the comments raised the project has been approved to proceed with the proposed amendments.

If your research project is a clinical trial and is being sponsored by the University or is to be conducted on a University of Sydney site, you must comply with additional University governance requirements prior to commencing your Clinical Trial.

Details of the approval are as follows:

Project Title:	**Health4Me: A community-based text message intervention to improve adolescent physical and mental health outcomes via primary care**
Project No.:	**2022/402**
Next Annual Report Due:	**30/06/2023**

New Approved Documents:

Date Uploaded	Version Number	Document Name
14/09/2022	Version 3	Health4Me Protocol_V2_14092022_CLEAN
14/09/2022	Version 3	Phase 1 PICF Parent Guardian_V2 14092022_CLEAN
14/09/2022	Version 3	Phase 2 PICF Parent Guardian_V2 14092022_CLEAN
14/09/2022	Version 3	Phase 2 PICF Young Person_V2 1409022_CLEAN
23/08/2022	Version 2	Phase 1 PICF Young Person_V2 23082022_CLEAN

Special Conditions of Approval for Clinical Trials

- **This letter constitutes ethical approval only.** This modification cannot proceed at any site until the necessary research governance authorisation is obtained. If your study is conducted on a University of Sydney site you must comply with additional University governance requirements prior to commencing your project at site. Please contact the Clinical Trials Governance Office at clinical-trials.research@sydney.edu.au

Please contact the Ethics Office should you require further information or clarification.

Sincerely,

Research Integrity & Ethics Administration
Research Portfolio
Level 3, F23 Administration Building
The University of Sydney
NSW 2006 Australia

T +61 2 9036 9161
E human.ethics@sydney.edu.au
W sydney.edu.au/ethics

ABN 15 211 513 464
CRICOS 00026A

THE UNIVERSITY OF SYDNEY

[redacted]

Dr Marinda Taha
Deputy Chair
Modification Review Committee (MRC 1)

The University of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2018) and the NHMRC's Australian Code for the Responsible Conduct of Research (2018).

THE UNIVERSITY OF SYDNEY

Research Integrity & Ethics Administration
HUMAN RESEARCH ETHICS COMMITTEE

Tuesday, 19 September 2023

Dr Stephanie Partridge
Health Sciences; Faculty of Medicine and Health
Email: stephanie.partridge@sydney.edu.au

Dear Stephanie,

Your request to modify this project, which was submitted on **18/08/2023**, has been considered.

After consideration of your response to the comments raised the project has been approved to proceed with the proposed amendments.

If your research project is a clinical trial and is being sponsored by the University or is to be conducted on a University of Sydney site, you must comply with additional University governance requirements prior to commencing your Clinical Trial.

Details of the approval are as follows:

Project Title: **Health4Me: A community-based text message intervention to improve adolescent physical and mental health outcomes via primary care**

Project No.: **2022/402**

Next Annual Report Due: **30/06/2024**

New Approved Documents:

Date Uploaded	Version Number	Document Name
13/09/2023	v.3	Phase 2 PICF Parent Guardian_V3 130923_CLEAN
13/09/2023	v.3	Phase 2 PICF Young Person_V3 130923_CLEAN
18/08/2023	v.3	Health4Me Protocol_V3_170823_CLEAN
18/08/2023	v.2	Phase 3_Focus Group Discussion Guide - V2 170823_CLEAN
18/08/2023	v.1	Phase 3_Focus Group Invite - V1 180823

Special Conditions of Approval for Clinical Trials

- **This letter constitutes ethical approval only.** This modification cannot proceed at any site until the necessary research governance authorisation is obtained. If your study is conducted on a University of Sydney site you must comply with additional University governance requirements prior to commencing your project at site. Please contact the Clinical Trials Governance Office at clinical-trials.research@sydney.edu.au

Please contact the Ethics Office should you require further information or clarification.

Sincerely,

[redacted]

Dr Marinda Taha
Chair
Modification Review Committee Chair (MRC 1)

The University of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2018) and the NHMRC's Australian Code for the Responsible Conduct of Research (2018).

Research Integrity & Ethics Administration
Research Portfolio
Level 3, F23 Administration Building
The University of Sydney
NSW 2006 Australia

T +61 2 9036 9161
E human.ethics@sydney.edu.au
W sydney.edu.au/ethics

ABN 15 211 513 464
CRICOS 00026A

Participant Information Sheet and Consent Form – Health4Me Co-Design (Parent Guardian)

Research Study: Phase 1: HEALTH4ME Text Message Development

Dr Stephanie Partridge (Head Researcher)
Phone: +61 412 961 432| Email: stephanie.partridge@sydney.edu.au
Ms Rebecca Raeside (research student)
Phone: +61 412 961 432 | Email: rebecca.raeside@sydney.edu.au

1. What is this study about?

We are conducting a research study about whether sending text messages with health information which promote a healthy lifestyle can help young people to improve their physical and mental health and wellbeing. First, we need young people to rate the text messages to find out whether they are useful, relevant, easy to understand and appropriate for people aged 12-18 years.

Your child has been invited to take part. Taking part in this study is voluntary.

Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

2. Who is running the study?

The study is being carried out by the following researchers:

- Dr Stephanie Partridge, Senior Research Fellow
  Engagement and Co-design Research Hub, School of Health Sciences, Faculty of Medicine and Health, University of Sydney

Rebecca Raeside is conducting this study as the basis for the degree of Doctor of Philosophy at The University of Sydney.

This study is being funded by a Medical Research Future Fund (MRFF) Primary Care Grant (MRFF2006315).

3. Who can take part in the study?

We are seeking young people aged 12-18 years to rate and review text messages that will later be tested in the HEALTH4ME Study.

Your child has been invited to take part in this study because they are within this age group and

4. What will the study involve?

If you decide your child can take part in this study:

- You and your child will be asked to sign the Participant Information and Consent Form
- They will fill out a short survey where they will be asked:
  - Date of birth
  - Gender

    - Aboriginal or Torres Strait Islander origin
    - Suburb and postcode
    - Language spoken at home
    - Education level
- They will then rate 15-20 text messages to say if they are useful, relevant, easy to understand and appropriate for their age. They can also suggest how to improve the text message.
- If needed, our study researcher will be available to help your child complete the questionnaire.

5. Can we withdraw once started?

Being in this study is completely voluntary and your child does not have to take part. They will also be asked if they agree to take part if you decide they can.

Any decision will not affect current or future relationships with the researchers or anyone else at The University of Sydney.

If you and your child decide to take part in the study and either of you change your mind, you can withdraw by stopping completion of the survey.

If you or your child decide to withdraw, we will not collect any more information. Any information that we have already collected will be kept in our study records and may be included in the study results.

6. Are there any risks or costs?

Aside from giving up time, we do not expect that there will be any risks or costs associated with taking part in this study for your child, nor will they be paid. If the study makes your child feel upset, you or your child may stop the study at any time. You will be provided with information and contacts your child can talk to, if that is what they want to do.

7. Are there any benefits?

This study aims to improve information that will be sent via text messages to young people. Reading and reviewing the information may or may not directly benefit your child. If the text message review is completed, your child will be offered a $30 voucher from JB HIFI or The Iconic as a reimbursement for their time to participate in the study. If study activities are incomplete, they will not be eligible to receive the voucher.

8. What will happen to information that is collected?

By providing your consent, you are agreeing to us collecting information about your child for the purposes of this study.

Any information provided to us will be stored securely and we will only disclose it with your permission, unless we are required by law to release information. We are planning for the study findings to be published.

Your child will not be individually identifiable in these publications.

All the information collected will be stored in a secure web application called REDCap (Research Electronic Data Capture). This system is managed by the University of Sydney. The researchers will use this to improve the text messages but no-one else will be allowed to use this information. The information your child tells us will be stored for 15 years from the time the study is completed. After 15 years all the computer files will be deleted.

9. Will I be told the results of the study?

You and your child have a right to receive feedback about the overall results of this study. If you would like to receive feedback, you can let us know on the consent form. This feedback will be in the form of a lay summary.

10. What if I would like further information?

When you have read this information, the following researcher/s will be available to discuss it with you further and answer any questions you may have. If you or your child would like to know more at any stage, please feel free to contact:

- Ms Rebecca Raeside, Research Associate
  Email: rebecca.raeside@sydney.edu.au
  Mobile: +61 412 961 432

11. What if I have a complaint or any concerns?

The ethical aspects of this study have been approved by the Human Research Ethics Committee (HREC) of The University of Sydney [2022/402] according to the *National Statement on Ethical Conduct in Human Research (2007).*

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the University:

Human Ethics Manager
human.ethics@sydney.edu.au
+61 2 8627 8176

This information sheet is for you to keep

Parent/Guardian Consent Form

Research Study: HEALTH4ME Text Message Development

Dr Stephanie Partridge (Head Researcher)
Phone: +61 412 961 432| Email: stephanie.partridge@sydney.edu.au
Ms Rebecca Raeside (research student)
Phone: +61 412 961 432 | Email: rebecca.raeside@sydney.edu.au

Participant Name _____

Parent/Guardian Name _____

Guardianship Status (parent/carer/legal guardian) _____

I agree my child may take part in this research study.

In giving my consent, I confirm that that:

- The details of any involvement have been explained to me, and I have been provided with a written Participant Information Statement to keep.
- I understand the purpose of the study is to investigate whether text messages to be tested in HEALTH4ME Study are useful, relevant, easy to understand and appropriate for young people.
- I acknowledge that the risks and benefits of participating in this study have been explained to me to my satisfaction.
- I understand that in this study my child will be required to fill out a short survey and rate 15-20 text messages.
- I understand that being in this study is completely voluntary.
- I am assured that my decision to let my child will not have an impact on any relationship with the research team or the University of Sydney.
- I understand that myself and my child are free to withdraw from this study at any time.
- I have been informed that the confidentiality of the information provided by my child will be protected and will only be used for purposes that has been agreed to. I understand that information will only be told to others with my permission, except as required by law.
- I understand that the results of this study may be published, and that publications will not contain any identifiable information about my child.

I would like feedback on the overall results of this study Yes ☐ No ☐

If you answered **yes**, please provide your preferred contact details (email/telephone):

_____

_____

_____

_____

- I understand that after I sign and return this consent form it will be retained by the researcher, and that I may request a copy at any time.

Parent/Guardian Name _____

Signature _____

Date _____

Participant Information Sheet and Consent Form – Health4Me Co-Design (Young Person)

Research Study:
Phase 1: HEALTH4ME Text Message Development

Dr Stephanie Partridge (Head Researcher)
Phone: +61 412 961 432| Email: stephanie.partridge@sydney.edu.au
Ms Rebecca Raeside (research student)
Phone: +61 412 961 432 | Email: rebecca.raeside@sydney.edu.au

---

Hello! Our names are:

- Dr Stephanie Partridge (Head Researcher)
- Ms Rebecca Raeside (Research Student)

1. What is this about?

We are doing a study about whether sending text messages with health information which promote a healthy lifestyle can help young people, like you, to improve their physical and mental health and wellbeing. First, we need young people to rate the text messages to find out whether they are useful, relevant, easy to understand and appropriate for your age.

We have asked you to be a part of our study because you are a young person aged 12-18 years old.

You can choose to take part, but you don't have to. This sheet will tell you more about what will happen so you can make up your mind.

If you have any questions you can ask us, or you can talk to someone else who looks after you. If you want to, you can call or text us on 0412 961 432.

2. What will happen if I say yes?

If you decide you want to be in our study, this is what will happen:

- You will be asked to sign the Participant Information and Consent Form
- You will fill out a short survey where you will be asked:
  - Date of birth

    - Gender
    - Aboriginal or Torres Strait Islander origin
    - Suburb and postcode
    - Language spoken at home
    - Education level
- You will then rate 15-20 text messages to say if they are useful, relevant, easy to understand and appropriate for your age. You can also suggest how to make the text message better.
- The text messages that have a high rating will be used in the HEALTH4ME study, those that have a low rating will be edited or deleted.

3. What are the good or bad things about the study?

The study will take up some of your time, but we don't think it will upset you or cost you anything.

For taking part in the study, you will be able to receive a gift voucher from JB HIFI or The Iconic. If you do not complete the text message review, you aren't able to receive the voucher. Once we have finished the study, we will let you know what we found out.

4. What are your rights?

Whatever we see today and what you tell us is private. All the information collected from you will be stored in a secure web application called REDCap (Research Electronic Data Capture). This system is managed by the University of Sydney. The researchers will use this to improve the text messages but no-one else will be allowed to use this information. The information you tell us will be stored for 15 years from the time the study is completed. After 15 years all the computer files will be deleted.

We will write about the things we learn from you in reports or papers about the research, but we won't use your name and we won't say anything that could tell other people who you are.

If you change your mind that's ok. It won't change how we feel about you. All you have to do is tell us you don't want to be part of the study anymore and we won't use anything you tell us. But this needs to happen before we finish the report about the study.

If you have any questions about the study you can talk to

- Ms Rebecca Raeside, Research Associate
  Email: rebecca.raeside@sydney.edu.au

Mobile: +61 412 961 432

5. What if I am not happy about the study?

If you are not happy with how we are doing the study and want to contact someone else, you can:

- **Call** the university on +61 2 8627 8176
- **Email** the manager at human.ethics@sydney.edu.au

This sheet is for you to keep

Study Consent Form

Research Study:
HEALTH4ME Text Message Development

Dr Stephanie Partridge (Head Researcher)
Phone: +61 412 961 432| Email: stephanie.partridge@sydney.edu.au
Ms Rebecca Raeside (research student)
Phone: +61 412 961 432 | Email: rebecca.raeside@sydney.edu.au

Participant Name _____

If you are happy to be in this study, please

- **Check** your **name** is in the space above
- **Sign** your **name** at the bottom of the next page
- **Provide** your **contact details** if you would like to know what we learn

By saying yes to being in this study, I am saying that:

- I know what I will be asked to do and have been given a Study Information Sheet to keep.
- I know that this study is about rating text messages for the HEALTH4ME Study to find out whether they are useful, relevant, easy to understand and appropriate for people my age.
- Someone has talked to me about the study and what it means for me.
- I know that I will be asked to fill out a short survey and rate 15-20 text messages
- I know that I don't have to be in the study if I don't want to.
- I know that I can choose not to talk about something if I don't want to.
- I have been told that I can change my mind at any time if I don't want to take part anymore.

- I have been told that if I say yes or no it won't change how the study team feel about me.

- I know that what I say or do in this study is private and when the study team write about what they learn they won't use my name or anything that could tell other people who I am.

- I understand that after I sign and return this consent form it will be kept by the researcher, and that I can ask for a copy at any time.

Your Name _____

Your Signature _____

Today's Date _____

We would like to tell you what we learned once we finish the study. How can we contact you to tell you what we found out? (write email address or phone number)

_____

_____

_____

_____

Participant Information Sheet and Consent Form – Health4Me Co-Design (Expert)

Research Study: Phase 1: HEALTH4ME Text Message Development

Dr Stephanie Partridge (Head Researcher)
Phone: +61 412 961 432| Email: stephanie.partridge@sydney.edu.au
Ms Rebecca Raeside (research student)
Phone: +61 412 961 432 | Email: rebecca.raeside@sydney.edu.au

1. What is this study about?

We are conducting a research study about whether sending text messages with health information which promotes a healthy lifestyle can help young people to improve their physical and mental health and wellbeing. First, we need young people to rate the text messages to find out whether they are useful, relevant, easy to understand and appropriate for people aged 12-18 years. Taking part in this study is voluntary.

Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

2. Who is running the study?

The study is being carried out by the following researchers:

- Dr Stephanie Partridge, Senior Research Fellow
  Engagement and Co-design Research Hub, School of Health Sciences, Faculty of Medicine and Health, University of Sydney

Rebecca Raeside is conducting this study as the basis for the degree of Doctor of Philosophy at The University of Sydney.

This study is being funded by a Medical Research Future Fund (MRFF) Primary Care Grant (MRFF2006315).

3. Who can take part in the study?

We are seeking clinical and research experts, including but not limited to dieticians, physiotherapists, psychologists, exercise physiologists, public health researchers, general practitioners and behavioural science experts to rate and review text messages that will later be tested in the HEALTH4ME Study.

You have been invited to take part in this study because you fit into the following category.

4. What will the study involve for me?

If you decide to take part in this study, you will be asked to:

- Sign the Participant Information and Consent Form
- Fill out a short survey where you will be asked:
  - Date of birth
  - Gender
  - Area of expertise

- You will then rate 15-20 text messages online to say if they are useful, relevant, easy to understand and appropriate for 12–18-year-olds. You can also suggest how to improve the text message.

5. Can I withdraw once I've started?

Being in this study is completely voluntary and you do not have to take part.

Your decision will not affect your current or future relationship with the researchers or anyone else at The University of Sydney.

If you decide to take part in the study and then change your mind you can withdraw by stopping completion of the survey.

If you decide to withdraw, we will not collect any more information from you. Any information that we have already collected will be kept in our study records and may be included in the study results.

6. Are there any risks or costs?

Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study. You will not be paid.

7. Are there any benefits?

This study aims to improve information that will be sent via text messages to young people. You will not receive any direct benefits from being in the study.

8. What will happen to information that is collected?

By providing your consent, you are agreeing to us collecting information about you for the purposes of this study.

Any information you provide us will be stored securely and we will only disclose it with your permission, unless we are required by law to release information. We are planning for the study findings to be published.

You will not be individually identifiable in these publications.

All the information collected will be stored in a secure web application called REDCap (Research Electronic Data Capture). This system is managed by the University of Sydney. The researchers will use this to improve the text messages but no-one else will be allowed to use this information. The information you tell us will be stored for 15 years from the time the study is completed. After 15 years all the computer files will be deleted.

9. Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. If you would like to receive feedback, you can let us know on the consent form. This feedback will be in the form of a brief lay summary.

10. What if I would like further information?

When you have read this information, the following researcher/s will be available to discuss it with you further and answer any questions you may have:

- Ms Rebecca Raeside, Research Associate
  Email: rebecca.raeside@sydney.edu.au

Mobile: +61 412 961 432

11. What if I have a complaint or any concerns?

The ethical aspects of this study have been approved by the Human Research Ethics Committee (HREC) of The University of Sydney [2022/402] according to the *National Statement on Ethical Conduct in Human Research (2007).*

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the University:

Human Ethics Manager
human.ethics@sydney.edu.au
+61 2 8627 8176

This information sheet is for you to keep

Participant Consent Form

HEALTH4ME Text Message Development

Dr Stephanie Partridge (Head Researcher)
Phone: +61 412 961 432 | Email: stephanie.partridge@sydney.edu.au
Ms Rebecca Raeside (research student)
Phone: +61 412 961 432 | Email: rebecca.raeside@sydney.edu.au

Participant Name _____

I agree to take part in this research study. In giving my consent, I confirm that that:

- The details of my involvement have been explained to me, and I have been provided with a written Participant Information Statement to keep.
- I understand the purpose of the study is to investigate whether text messages to be tested in HEALTH4ME Study are useful, relevant, easy to understand and appropriate for young people.
- I acknowledge that the risks and benefits of participating in this study have been explained to me to my satisfaction.
- I understand that in this study I will be required to fill out a short survey and rate 15-20 text messages.
- I understand that being in this study is completely voluntary.
- I am assured that my decision to participate will not have any impact on my relationship with the research team or the University of Sydney.
- I understand that I am free to withdraw from this study at any time and that I can choose to withdraw any information I have already provided (unless the data has already been de-identified or published).
- I have been informed that the confidentiality of the information I provide will be protected and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.
- I understand that the results of this study may be published, and that publications will not contain my name or any identifiable information about me.

I would like feedback on the overall results of this study Yes ☐ No ☐

If you answered **yes**, please provide your preferred contact details (email/telephone):

_____

_____

_____

- I understand that after I sign and return this consent form it will be retained by the researcher, and that I may request a copy at any time.

Participant Name _____

Signature _____

Date _____

Participant Information Sheet and Consent Form – Health4Me RCT (Parent Guardian)

Research Study - Phase 2: HEALTH4ME Study

Dr Stephanie Partridge
Engagement and Co-design Research Hub, School of Health Sciences, Faculty of Medicine and Health
Phone: +61 468 684 450 | Email: stephanie.partridge@sydney.edu.au

1. What is this study about?

We are conducting a research study about whether a text message healthy lifestyle program (HEALTH4ME) with optional health counselling will help young people to improve their physical and mental health. We aim to test whether receiving the text message program with optional health counselling is better at improving physical and mental health outcomes, compared to receiving no text message program. Finding this out is important so we can provide programs to all young people to create healthy life-long habits and prevent chronic diseases. Taking part in this study is voluntary.

Your child has been invited to take part in this study because they are a young person with an active mobile phone and free from any chronic health conditions.

Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

2. Who is running the study?

The study is being carried out by the following researchers:

- Dr Stephanie Partridge, Senior Research Fellow, Engagement and Co-design Research Hub, School of Health Sciences, Faculty of Medicine and Health, University of Sydney

Rebecca Raeside is conducting this study as the basis for the degree of Doctor of Philosophy at The University of Sydney.

This study is being funded by a Medical Research Future Fund (MRFF) Primary Care Grant (MRFF2006315).

3. Who can take part in the study?

We are looking for young people aged 12-18 years who own a mobile phone which can send and receive text messages and with sufficient English to read at a 7th grade level to take part in the study.

Young people are not able to take part if they:

- have a diagnosis of type 1 or type 2 diabetes mellitus;
- have a medical condition that would make them incapable of providing informed consent;
- if they are enrolled in an alternative randomised lifestyle management program;
- have a previous or current diagnosis of an eating disorder OR at high risk for an eating disorder as assessed in screening;
- have had recent rapid weight loss;
- have weight <25th BMI centile for their age;
- are pregnant or planning to become pregnant in the next 6-months or;
- are unable to read English at a 7th grade level

This is because people with these conditions require care above and beyond what this program is designed to offer.

4. What will the study involve for me?

Please note: this study involves no in-person activities, everything will be completed online including via phone call, text message, email or videoconference.

The study is 6 months long. Sometimes we do not know which intervention is best for helping people with improve their health. To find out we need to compare different groups. The computer system will randomly (like flipping a coin) assign your child to either receive text messages right away (intervention group) or no messages until after the 6-month follow-up (control group). They will have a 50% chance of being in the intervention group or the control group. They will be notified of which group you are in via text message.

It is not possible for them to choose the group. Nor will they be able to change groups at any time. Our study is a single-blind randomised controlled trial. This means the researchers do not know which group they are assigned to. So please avoid telling them. We designed the study this way to make sure the researchers interpret the results in a fair and suitable way. At the end of the study, the results are compared to see if receiving text message intervention helps improve young people's physical and mental health more than not receiving any text messages.

If you and your child decide to take part in this study, they will be asked to:

1. Complete a short screening process online (15 minutes);
2. Co-sign the Participant Information and Consent Form electronically;
3. Complete enrolment online (45 minutes) which will involve:
    a. Self-reported clinical measurements including height, weight and waist circumference
    b. The following questionnaires (if needed, our research team will be available at a time suitable to your child to help them complete them)

Questionnaire topic	**# Questions**	**Minutes to complete**
Demographics	11	2 min
Diet quality, food choices and food patterns	134	15 min
Physical activity levels	5	2 min
Sedentary activity	4	3 min
Sleep quality	7	3 min
Quality of life	9	3 min
Self-efficacy	16	4 min
Anxiety	7	2 min
Depression	10	2 min
Psychological distress	6	2 min
Eating disorders	6	2 min
Food insecurity	6	2 min
eHealth literacy	10	3 min
Feedback on the program*	27	10 min
Focus group**	-	45 min
Total time Enrolment	**-**	**45 min**
Total time 6-month follow-up	**-**	**45-55 min**
Total time focus group	**-**	**45 min**

* Only collected at 6-month follow-up.

** Focus groups are optional and only for those in the intervention group

   c. Your child will then be sent an activity tracker to wear for 7 days and then return it to the research team via a pre-paid post bag which will be provided
   d. Once the research team receive the activity tracker back and all enrolment items are complete, they will be issued their first gift card as a reimbursement for their time

4. Approximately 1-3 days after the research team receive the activity tracker back, your child will receive a "welcome to the study" text message. This will tell them which group they are in (either the intervention or control group).
   a. If they are in the intervention group, they will receive 4-5 text messages per week with positive and encouraging advice and information about keeping healthy habits including messages on healthy eating, physical activity, sleep and mental wellbeing. The messages are designed to support your child and they may save, share or delete the messages, if they'd like.
   b. All text messages will be sent at appropriate times. If they are attending high school, the weekday messages will only be sent before school between 7.30am to 8.30am or after school hours from 3.30pm to 7.30pm.
   c. Intervention participants will also have the opportunity to talk to a university qualified health counsellor once per month (6 calls in total). Each month, intervention participants will be sent a text message encouraging them to call the health counsellor and ask questions or request additional information. The health counsellor will monitor and respond to participants requests within 3 working days. The calls will allow participants to set goals, discuss challenges and their overall progress.
   d. If they are in the control group, they will not receive any text messages or health counselling calls for 6-months.

All participants will receive a text message after 6-months. This will state that someone from the research team will contact your child to complete your 6-month follow up online.

5. Complete 6-month follow up (45-55 minutes) which will involve:
   a. Self-reported clinical measurements including height, weight and waist circumference
   b. The same questionnaires as the enrolment, including a feedback survey about what your child liked and disliked about the study
   c. They will once again be sent an activity tracker to wear for 7 days, then return to the research team via a pre-paid post bag provided by the research team.
   d. Once the research team receive the activity tracker back and all 6-month follow-up items are complete, your child will be issued their second gift card as a reimbursement for their time

6. Focus groups (optional): If your child received the text message intervention, they will be invited to a focus group via Zoom teleconference with study researchers and other participants who received the intervention. This will be at the end of the intervention (6-months) to discuss what they liked and disliked about the text messages, so we can improve them for future use. We would like to make you and your child aware that this session will be audiotaped for research purposes and will last about 45 minutes.

5. Can I withdraw once I've started?

Being in this study is completely voluntary and your child does not have to take part if they don't want to.

The decision will not affect you or your child's current or future relationship with the researchers or anyone else at The University of Sydney.

If you and your child decide to take part in the study and then change your mind they can withdraw at any time by letting one of the researchers know by phone or email or by replying 'STOP' to any of the text messages. Once they reply 'STOP' their request will be processed by one of the researchers as soon as possible, usually within 72 hours. Your child also doesn't need to answer any questions that they don't want to.

If they choose to withdraw, we will not collect any more information from your child. Please let us know at the time they withdraw what you would like us to do with information we have collected about your child up to that point.

6. Are there any risks or costs?

We do not expect any side effects or risks by taking part in our study. However, questionnaires relating to your child's emotional health may be distressing and may reveal an undiagnosed eating disorder. If this happens, they will be referred to the Inside Out Institute for Eating Disorders with a letter from us. If anything your child talks about during the study makes them feel upset, they may stop the study at any time, they will be provided with information and contacts they can talk to, if that's what they want to do. The researcher can help your child do that. Here are other contacts that your child can talk to and websites they can access if they feel distressed or upset.

Kids Helpline:	*T: 1800 551 800*	*W: kidshelpline.com.au*
Lifeline	*T: 13 11 14*	*W: lifeline.org.au*
The Butterfly Foundation:	*T: 1800 334 673*	*W: thebutterflyfoundation.org.au*
ReachOut:		*W: au.reachout.com*
HeadSpace:		*W: headspace.org.au*

The only time the researchers would have to tell someone is if anyone hurt your child or upset them in any way. The researchers would also have to tell someone if your child said they might hurt themself or someone else. If any of those things happen, they would have to call the child protection helpline run by the NSW Government Family and Community Services.

7. What happens when the study ends?

At the end of the 6-month follow-up, the text messages will be offered to those in the control group to receive free-of-charge, if they would like to receive them.

8. Are there any benefits?

This study aims to further medical knowledge about whether text message programs are helpful to young people and may improve your child's physical and mental health, however it may or may not directly benefit your child. If all study activities and follow-ups are completed at baseline and 6-months, your child will be offered a $30 voucher at each time point from JB HIFI or The Iconic as a reimbursement for their time to participate in the study ($60 total). If they choose to withdraw from the study or study activities and follow-ups are incomplete, they will not be eligible to receive the voucher. If your child decides to take part in the optional focus group, they will be offered a $50 gift voucher as reimbursement for their time to take part in this phase of the study. All gift vouchers will be distributed via email.

9. What will happen to information that is collected?

By providing your consent, you are agreeing to us collecting information about your child for the purposes of this study. Research staff will only collect and use personal information about your child that is relevant to the study. Once your child has been assigned to the

intervention or control group, they will be given a study identification number which will be used on all the study documents instead of their name. Information collected from your child will be stored in a secure web application called REDCap. This system is managed by the University of Sydney and will be used to send out the text messages and analyse information collected during the study. If your child chooses to take part in the focus groups at the end of the study, these sessions will be audio recorded and stored on secure research data stores within the University of Sydney.

Any information your child provide us will be stored securely and only disclosed with your permission, unless we are required by law to disclose material. We anticipate study findings will be published and we plan to discuss the results at scientific meetings. Your child will not be individually identifiable in these publications.

All information collected during the study that can identify your child will be treated confidential in accordance with Australian privacy laws. Confidential data will be stored for a period of 20 years from the time of the study is completed, or until the youngest child in the study turns 25 (whichever is the longest). This information will only be accessible to study investigators. After this time, computer files will be deleted. In accordance with relevant Australian and New South Wales privacy and other relevant laws, you have the right to request access to your child's information collected and stored by the research team. You also have the right to request that any information which you or your child disagrees with be corrected. Please contact the study team member named at the end of this document if you would like to access your child's information.

This study will be conducted in compliance with all conditions of this protocol. As well as the conditions of the ethics committee approval, the NHMRC National Statement on ethical Conduct in Human Research (2007) and the Note for Guidance on Good Clinical Practice (CPMP/ICH-135/95).

10. Will I be told the results of the study?

You and your child have a right to receive feedback about the overall results of this study. We will ask a question in the consent form so you can let us know whether you'd like to receive results of the study one they are available, although this may take some time. This feedback will be in the form of a brief lay summary.

11. What if I would like further information?

When you have read this information, the following researcher/s will be available to further discuss it with you and/or your child and answer any questions you may have:

- Ms Rebecca Raeside, Research Associate
  E: rebecca.raeside@sydney.edu.au
  M: +61 468 684 450

12. What if I have a complaint or any concerns?

The ethical aspects of this study have been approved by the Human Research Ethics Committee (HREC) of The University of Sydney 2022/402 according to the *National Statement on Ethical Conduct in Human Research (2007).*

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the University:

Human Ethics Manager
human.ethics@sydney.edu.au

+61 2 8627 8176

This information sheet is for you to keep

Participant Consent Form

Research Study - Phase 2: HEALTH4ME Study

Dr Stephanie Partridge
Engagement and Co-design Research Hub, School of Health Sciences, Faculty of Medicine and Health
Phone: +61 468 684 450| Email: stephanie.partridge@sydney.edu.au

Participant Name _____

I agree for my child to take part in this research study. In giving my consent, I confirm that that:

- The details of my child's involvement have been explained to me, and I have been provided with a written Participant Information Statement to keep.
- I understand the purpose of the study is to investigate whether a text message healthy lifestyle program (HEALTH4ME) with optional health counselling will help young people to improve their physical and mental health and wellbeing.
- I acknowledge that the risks and benefits of participating in this study have been explained to me to my satisfaction.
- I understand that in this study my child will be required to complete the screening, enrolment and 6-month follow up online including self-reported clinical measurements and surveys; and if selected for the intervention group, receive text messages for 6-months designed to support and improve a physical and mental health and wellbeing.
- I understand that if my child participates in the focus groups the audio will be taped and stored securely.
- I understand that being in this study is completely voluntary.
- I am assured that my decision for my child to participate will not have any impact on my relationship with the research team or the University of Sydney.
- I understand that my child is free to withdraw from this study at any time and that we can choose to withdraw any information that has already provided (unless the data has already been de-identified or published).
- I have been informed that the confidentiality of the information my child provides will be protected and will only be used for purposes that we have agreed to. I understand that information about my child will only be told to others with our permission, except as required by law.
- I understand that the results of this study may be published, and that publications will not contain my child's name or any identifiable information about them.

- I confirm the following:

I consent to audio recordings Yes ☐ No ☐

I consent to being contacted for future studies Yes ☐ No ☐

I would like feedback on the overall results of this study Yes ☐ No ☐

If you answered **yes**, please provide your preferred contact details (email/telephone):

_____

_____

_____

- I understand that after we sign and return this consent form it will be retained by the researcher, and that we may request a copy at any time.

Participant Name _____

Participant Signature _____

Date _____

Parent/Guardian Name _____

Parent/Guardian Signature _____

Date _____

Participant Information Sheet and Consent Form – Health4Me RCT (Young Person)

Research Study - Phase 2: HEALTH4ME Study

Dr Stephanie Partridge
Engagement and Co-design Research Hub, School of Health Sciences, Faculty of Medicine and Health
Phone: +61 468 684 450| Email: stephanie.partridge@sydney.edu.au

1. What is this study about?

We are conducting a research study about whether a text message healthy lifestyle program (HEALTH4ME) with optional health counselling will help young people to improve their physical and mental health. We aim to test whether receiving the text message program with optional health counselling is better at improving physical and mental health outcomes, compared to receiving no text message program. Finding this out is important so we can provide programs to all young people to create healthy life-long habits and prevent chronic diseases. Taking part in this study is voluntary.

You have been invited to take part in this study because you are a young person with an active mobile phone and free from any chronic (long-term) health conditions.

Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

2. Who is running the study?

The study is being carried out by the following researchers:

- Dr Stephanie Partridge, Senior Research Fellow
  Engagement and Co-design Research Hub, School of Health Sciences, Faculty of Medicine and Health

Rebecca Raeside is conducting this study as the basis for the degree of Doctor of Philosophy at The University of Sydney.

This study is being funded by a Medical Research Future Fund (MRFF) Primary Care Grant (MRFF2006315).

3. Who can take part in the study?

We are looking for young people aged 12-18 years who own a mobile phone which can send and receive text messages and with sufficient English to read at a 7th grade level to take part in the study.

You are not able to take part if you:

- have a diagnosis of type 1 or type 2 diabetes mellitus;
- have a medical condition that would make you incapable of providing informed consent;
- are enrolled in an alternative randomised lifestyle management program;
- have a previous or current diagnosis of an eating disorder OR at high risk for an eating disorder as assessed in screening;
- have had recent rapid weight loss;
- have weight <25th BMI centile for their age;
- are pregnant or planning to become pregnant in the next 6-months or;
- are unable to read English at a 7th grade level

This is because people with these conditions require care above and beyond what this program is designed to offer.

4. What will the study involve for me?

Please note: this study involves no in-person activities, everything will be completed online including via phone call, text message, email or videoconference.

This study is 6 months long. Sometimes we do not know which intervention is best for helping people with improve their health. To find out we need to compare different groups. The computer system will randomly (like flipping a coin) assign you to either receive text messages right away (intervention group) or no messages until after the 6-month visit (control group). You will have a 50% chance of being in the intervention group or the control group. You will be notified of which group you are in via text message.

It is not possible for you to choose the group. Nor will you be able to change groups at any time. Our study is a single-blind randomised controlled trial. This means the researchers do not know which group you are in. So please avoid telling them. We designed the study this way to make sure the researchers interpret the results in a fair and suitable way. At the end of the study, the results are compared to see if receiving text message intervention helps improve young people's physical and mental health more than not receiving any text messages.

If you decide to take part in this study, you will be asked to:

7. Complete a short screening process online (15 minutes);
8. Sign the Participant Information and Consent Form electronically;
9. Complete enrolment online (45 minutes) which will involve:
    a. Self-reported clinical measurements including height, weight and waist circumference
    b. The following questionnaires (if needed, our research team will be available at a time suitable to you to help you complete them)

Questionnaire topic	**# Questions**	**Minutes to complete**
Demographics	11	2 min
Diet quality, food choices and food patterns	134	15 min
Physical activity levels	5	2 min
Sedentary activity	4	3 min
Sleep quality	7	3 min
Quality of life	9	3 min
Self-efficacy	16	4 min
Anxiety	7	2 min
Depression	10	2 min
Psychological distress	6	2 min
Eating disorders	6	2 min
Food insecurity	6	2 min
eHealth literacy	10	3 min
Feedback on the program*	27	10 min
Focus group*	-	45 min
Total time Enrolment	**-**	**45 min**
Total time 6-month follow-up	**-**	**55 min**

Total time focus group	**-**	**45 min**

* Only collected at 6-month follow-up
** Focus groups are optional and only for those in the intervention group

c. You will then be sent an activity tracker to wear for 7 days and then return it to the research team via a pre-paid post bag which will be provided
d. Once the research team receive the activity tracker back and all enrolment items are complete, you will be issued your first gift card as a reimbursement for your time

10. Approximately 1-3 days after the research team receive the activity tracker back, you will receive a "welcome to the study" text message. This will tell you which group you are in (either the intervention or control group).
    a. If you are in the intervention group, you will receive 4-5 text messages per week with positive and encouraging advice and information about keeping healthy habits including messages on healthy eating, physical activity, sleep and mental wellbeing. The messages are designed to support you and you may save, share or delete the messages, if you'd like.
    b. All text messages will be sent at appropriate times. If you are attending high school, the weekday messages will only be sent before school between 7.30am to 8.30am or after school hours from 3.30pm to 7.30pm. If you are driving, please remember that you must not read the text messages or perform any other functions while driving.
    c. Intervention participants will also have the opportunity to talk to a university qualified health counsellor once per month (6 calls in total). Each month, intervention participants will be sent a text message encouraging them to call the health counsellor and ask questions or request additional information. The health counsellor will monitor and respond to participants requests within 3 working days. The calls will allow participants to set goals, discuss challenges and their overall progress.
    d. If you are in the control group, you will not receive any text messages or health counselling calls for 6-months.

All participants will receive a text message after 6-months. This will state that someone from the research team will contact you to complete your 6-month follow up online.

11. Complete 6-month follow up (45-55 minutes) which will involve:
    a. Self-reported clinical measurements including height, weight and waist circumference
    b. The same questionnaires as the enrolment, including a feedback survey about what you liked and disliked about the study
    c. You will once again be sent an activity tracker to wear for 7 days, then return to the research team via a pre-paid post bag provided by the research team.
    d. Once the research team receive the activity tracker back and all 6-month follow-up items are complete, you will be issued your second gift card as a reimbursement for your time

12. Focus groups (optional): If you received the text message intervention, you will be invited to a focus group via Zoom teleconference with study researchers and other participants who received the intervention. This will be at the end of the intervention (6-months) to discuss what you liked and disliked about the text messages, so we can improve them for future use. We would like to make you aware that this session will be audiotaped for research purposes and will last about 45 minutes.

5. Can I withdraw once I've started?

Being in this study is completely voluntary and you do not have to take part if you don't want to.

Your decision will not affect your current or future relationship with the researchers or anyone else at The University of Sydney.

If you decide to take part in the study and then change your mind you can withdraw at any time by letting one of the researchers know by phone or email or by replying 'STOP' to any of the text messages. Once you reply 'STOP' your request will be processed by one of the researchers as soon as possible, usually within 72 hours. You also don't need to answer any questions that you don't want to.

If you choose to withdraw, we will not collect any more information from you. Please let us know at the time you withdraw what you would like us to do with information we have collected about you up to that point.

6. Are there any risks or costs?

We do not expect any side effects or risks by taking part in our study. However, questionnaires relating to your emotional health may be distressing and may reveal an undiagnosed eating disorder. If this happens, you will be referred to the Inside Out Institute for Eating Disorders with a letter from us. If anything you talk about during the study makes you feel upset, you may stop the study at any time, Your parents/carers will be told and you will be provided with information and contacts you can talk to, if that's what you want to do. The researcher can help you do that. Here are other contacts that you can talk to and websites you can access if you feel distressed or upset.

Kids Helpline:	*T: 1800 551 800*	*W: kidshelpline.com.au*
Lifeline	*T: 13 11 14*	*W: lifeline.org.au*
The Butterfly Foundation:	*T: 1800 334 673*	*W: thebutterflyfoundation.org.au*
ReachOut:		*W: au.reachout.com*
HeadSpace:		*W: headspace.org.au*

The only time the researchers would have to tell someone is if anyone hurt you or upset you in any way. The researchers would also have to tell someone if you said you might hurt yourself or someone else. If any of those things happen, they would have to call the child protection helpline run by the NSW Government Family and Community Services.

7. What happens when the study ends?

At the end of the 6-month follow-up, the text messages will be offered to those in the control group to receive free-of-charge, if they would like to receive them.

8. Are there any benefits?

This study aims to further medical knowledge about whether text message programs are helpful to young people and may improve your physical and mental health, however it may or may not directly benefit you. If all study activities and follow-ups are completed at baseline and 6-months, you will be offered a $30 voucher from JB HIFI or The Iconic at each time point as a reimbursement for your time to participate in the study ($60 total). If you choose to withdraw from the study or study activities and follow-ups are incomplete, you will not be eligible to receive the voucher. If you decide to take part in the optional focus group, you will be offered a $50 gift voucher as reimbursement for your time to take part in this phase of the study. All gift vouchers will be distributed via email.

9. What will happen to information that is collected?

By providing your consent, you are agreeing to us collecting information about you for the purposes of this study. Research staff will only collect and use personal information about

you that is relevant to the study. Once you have been assigned to the intervention or control group, you will be given a study identification number which will be used on all the study documents instead of your name. Information collected from you will be stored in a secure web application called REDCap. This system is managed by the University of Sydney and will be used to send out the text messages and analyse information collected during the study. If you choose to take part in the focus groups at the end of the study, these sessions will be audio recorded and stored on secure research data stores within the University of Sydney.

Any information you provide us will be stored securely and only disclosed with your permission, unless we are required by law to disclose material. We anticipate study findings will be published and we plan to discuss the results at scientific meetings. You will not be individually identifiable in these publications.

All information collected during the study that can identify you will be treated confidential in accordance with Australian privacy laws. Confidential data will be stored for a period of 20 years from the time of the study is completed, or until the youngest child in the study turns 25 (whichever is the longest). This information will only be accessible to study investigators. After this time, computer files will be deleted, and paper files will be shredded. In accordance with relevant Australian and New South Wales privacy and other relevant laws, you have the right to request access to your information collected and stored by the research team. You also have the right to request that any information with which you disagree be corrected. Please contact the study team member named at the end of this document if you would like to access your information.

This study will be conducted in compliance with all conditions of this protocol. As well as the conditions of the ethics committee approval, the NHMRC National Statement on ethical Conduct in Human Research (2007) and the Note for Guidance on Good Clinical Practice (CPMP/ICH-135/95).

10. Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. We will ask a question in the consent form so you can let us know whether you'd like to receive results of the study one they are available, although this may take some time. This feedback will be in the form of a brief lay summary.

11. What if I would like further information?

When you have read this information, the following researcher/s will be available to discuss it with you further and answer any questions you may have:

- Ms Rebecca Raeside, Research Associate
  E: rebecca.raeside@sydney.edu.au
  M: +61 468 684 450

12. What if I have a complaint or any concerns?

The ethical aspects of this study have been approved by the Human Research Ethics Committee (HREC) of The University of Sydney 2022/402 according to the *National Statement on Ethical Conduct in Human Research (2007)*.

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the University:

Human Ethics Manager

human.ethics@sydney.edu.au

+61 2 8627 8176

This information sheet is for you to keep

Participant Consent Form

Research Study: HEALTH4ME Study

Dr Stephanie Partridge
Engagement and Co-design Research Hub, School of Health Sciences, Faculty of Medicine and Health
Phone: +61 412 961 432 | Email: stephanie.partridge@sydney.edu.au

Participant Name _____

I agree to take part in this research study. In giving my consent, I confirm that that:

- The details of my involvement have been explained to me, and I have been provided with a written Participant Information Statement to keep.
- I understand the purpose of the study is to investigate whether a text message healthy lifestyle program (HEALTH4ME) with optional health counselling will help young people to improve their physical and mental health and wellbeing.
- I acknowledge that the risks and benefits of participating in this study have been explained to me to my satisfaction.
- I understand that in this study I will be required to complete the screening, enrolment and 6-month follow up online including self-reported clinical measurements and surveys; and if selected for the intervention group, receive text messages for 6-months designed to support and improve a physical and mental health and wellbeing.
- I understand that if I participate in the focus groups the audio will be taped and stored securely.
- I understand that being in this study is completely voluntary.
- I am assured that my decision to participate will not have any impact on my relationship with the research team or the University of Sydney.
- I understand that I am free to withdraw from this study at any time and that I can choose to withdraw any information I have already provided (unless the data has already been de-identified or published).
- I have been informed that the confidentiality of the information I provide will be protected and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.
- I understand that the results of this study may be published, and that publications will not contain my name or any identifiable information about me.

- I confirm the following:

I consent to audio recordings Yes ☐ No ☐

I consent to being contacted for future studies Yes ☐ No ☐

I would like feedback on the overall results of this study Yes ☐ No ☐

If you answered **yes**, please provide your preferred contact details (email/telephone):

_____

_____

_____

- I understand that after I sign and return this consent form it will be retained by the researcher, and that I may request a copy at any time.

Participant Name _____

Participant Signature _____

Date _____

Health4Me RCT Recruitment Materials

Email to Youth Organisations

Good Morning,

We are researchers from The University of Sydney. We are conducting a study called Health4Me, a text message program to promote a healthy and happy lifestyle for adolescents aged 12-18 years. Finding motivation and correct information can be challenging for young people, which is why we are conducting a research study to understand whether text messaging is an effective way to support them. All the text messages were developed in conjunction with young people and reviewed by experts. We would like to invite your members to participate in our study.

The aim of Health4Me is to support improvements to young people's eating and physical activity behaviours, alongside focusing on other topics which young people identified as important to them, including mental health and sleep, body image, climate and planetary health and the media. Young people have the option to reply to any of the messages and to communicate with a health counsellor to receive more support. The study runs for 6-months, with students receiving 4-5 text messages per week (out of school hours). All study activities are conducted online. Young people can also receive up to $60 worth of gift vouchers for completing the study activities.

We would be grateful if you could include the attached study advertisement in your newsletter and/or share on your social media channels to introduce our study to your members.

Full study details are available on our website (www.health4mestudy.com). Thank you in advance for any assistance and please do not hesitate to contact us if you have any questions regarding the study.

Sincerely,

Health4Me Team

(Rebecca, Stephanie & Allyson)

Email to Schools

Dear Principal,

We are researchers from The University of Sydney. We are conducting a study called Health4Me, a text message program to promote a healthy and happy lifestyle for adolescents aged 12-18 years. Finding motivation and correct information can be challenging for young people, which is why we are conducting a research study to understand whether text messaging is an effective way to support them. All the text messages were developed in conjunction with young people and reviewed by experts. We would like to invite your students to participate in our study.

The aim of Health4Me is to support improvements to young people's eating and physical activity behaviours, alongside focusing on other topics which young people identified as important to them, including mental health and sleep, body image, climate and planetary health and the media. Young people have the option to reply to any of the messages and to communicate with a health counsellor to receive more support. The study runs for 6-months, with students receiving 4-5 text messages per week (out of school hours). All study activities are conducted online. Young people can also receive up to $60 worth of gift vouchers for completing the study activities.

We would be grateful if you could include the attached study advertisement in your school newsletter and/or share on your school social media channels to introduce our study to your students.

Full study details are available on our website (www.health4mestudy.com). Thank you in advance for any assistance and please do not hesitate to contact us if you have any questions regarding the study.

Sincerely,

Health4Me Team

(Rebecca, Stephanie & Allyson)

Email to Known Networks and Contacts

Good Afternoon,

You have recently expressed interest or taken part in a research study led by our team. Today, I'd like to tell you about a new research study which we have just launched called Health4Me!

Health4Me is a 6-month research study where you will receive 4-5 text messages per week for 6-months. We are aiming to find out whether taking part in the Health4Me program for 6-months can improve young people's physical and mental health. Our text messages have been developed with young people for young people! If you take part in the study, you will receive information and advice on areas including diet, physical activity, sleep, mental health, body image and climate and planetary health. YOU get to choose how much you want to interact with the program – you can reply to the messages and receive up to 6 coaching calls with a health counsellor if you like!

Best of all – everything is online! You will complete surveys at both the start and end of the study (6-months' time), wear an activity tracker which we will send to you and communicate with the researchers via text messages. If you complete all the study activities you will receive up to $60 in gift vouchers.

You may be eligible to take part in the study if you are between 12 and 18 years old and own an active mobile phone. To find out whether you are eligible, please fill out this short (5-min) screening form: https://redcap.sydney.edu.au/surveys/?s=8MLDKXRLDTN7RD83. A member of the research team will get in contact with you shortly after!

If you have any questions please reply to this email or send us a text at 0468 684 450.

Kind Regards,

Rebecca (on behalf of the Health4Me team)

Health4Me Study for adolescents aged 12-18 years

Researchers from the University of Sydney are conducting a study called Health4Me, a healthy lifestyle text message program for adolescents aged 12-18 years. The program has been co-designed by young people, for young people. The overall aim of the study is to support improvements to young people's eating and physical activity behaviours, alongside focusing on other topics which young people identified as important to them, including mental health and sleep, body image, climate and planetary health and the media.

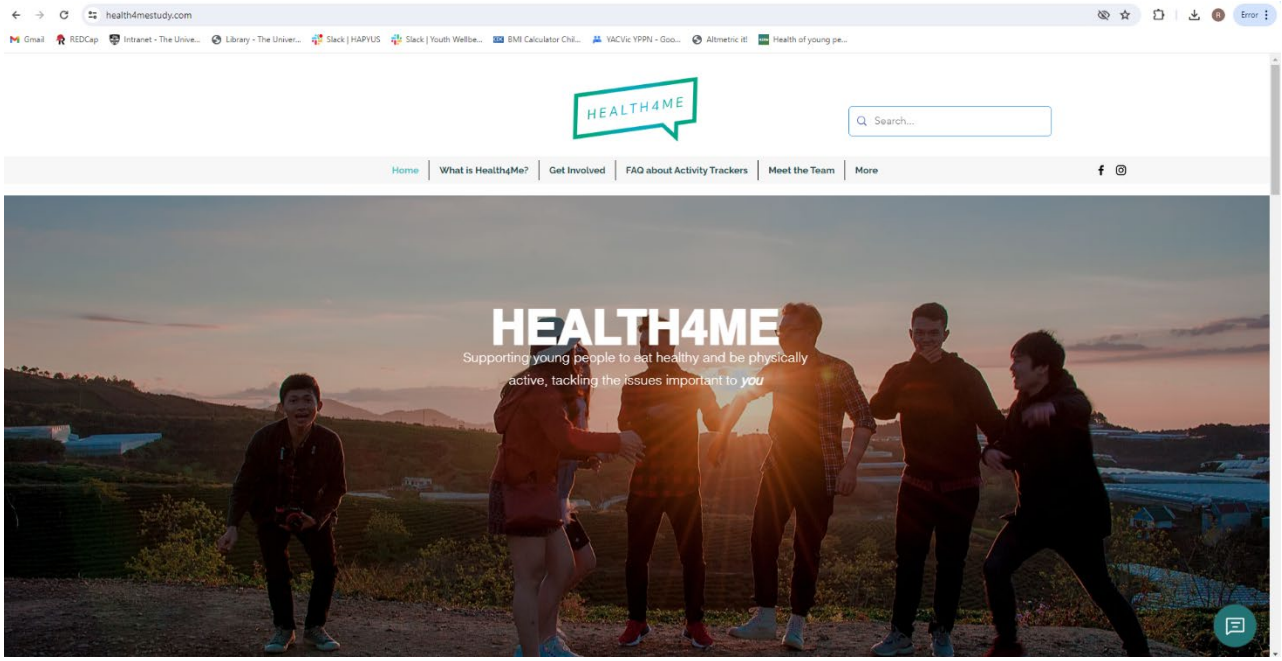
Young people have the option to reply to any of the messages and to communicate with a health counsellor to receive more support. The study runs for 6-months, with participants having the chance of receiving 4-5 text messages per week (out of school hours). All study activities are conducted online. Young people can also receive up to $60 worth of gift vouchers for completing the study activities.

We'd appreciate your help to spread the word! Young people can express interest for the study here.

They must be aged between 12-18 years old, have an active mobile phone and not have been diagnosed with diabetes or a previous or current eating disorder.

Full study details are available on our website. Thank you in advance for any assistance and please do not hesitate to contact Health4Me (+61 468 684 450) if you have any questions regarding the study.

Health4Me Website (Homepage)



Health4Me Study Flyer

Health4Me Social Media Advertisement Examples (Instagram and Facebook)

Appendix D – Health4Me Screening Questionnaires

InsideOut Institute Screener [IOI-S]

1. How is your relationship with food? *(For example: is food and eating worry free, or is it full of worry and stress?)*	□ 1 Worry and stress free □ 2 □ 3 □ 4 □ 5 Full of worry and stress
2. Does your weight, body or shape make you feel bad about yourself? *(For example: the number on the scale, the shape of your body or a part of your body.)*	□ 1 Never □ 2 □ 3 □ 4 □ 5 All the time
3. Do you feel like food, weight or your body shape dominates your life? *(For example: experiencing constant thoughts about food, weight or your body.)*	□ 1 Never □ 2 □ 3 □ 4 □ 5 All the time
4. Do you feel anxious or distressed when you are not in control of your food? *(For example: when others cook or prepare food for you or when eating out.)*	□ 1 Never □ 2 □ 3 □ 4 □ 5 All the time
5. Do you ever feel like you will not be able to stop eating or have lost control around food? *(For example: feeling that you have no control around food, that you binge eat or fear that you will binge eat.)*	□ 1 Never □ 2 □ 3 □ 4 □ 5 All the time
6. When you think you have eaten too much, do you do anything to make up for it? *(For example: skipping the next meal, going light on the next meal, working it off with exercise, purging via vomiting or taking laxatives, diuretics or diet pills.)*	□ 1 Never □ 2 □ 3 □ 4 □ 5 All the time

Note: Items are rated on a 5-point Likert scale to give a total score out of 30

If score on IOI-S >16, participant must complete a 28-item EDE-Q. Otherwise, participant may be included.

Eating Disorder Examination Questionnaire [EDE-Q]

On how many of the past 28 days…	
1. Have you been deliberately trying to limit the amount of food you eat to influence your shape or weight (whether or not you have succeeded)?	□ No days □ 1-5 days □ 6-12 days □ 13-15 days □ 16-22 days □ 23-27 days □ Everyday
2. Have you gone for long periods of time (8 waking hours or more) without eating anything at all in order to influence your shape or weight?	□ No days □ 1-5 days □ 6-12 days □ 13-15 days □ 16-22 days □ 23-27 days □ Everyday
3. Have you tried to exclude from your diet any foods that you like in order to influence your shape or weight (whether or not you have succeeded)?	□ No days □ 1-5 days □ 6-12 days □ 13-15 days □ 16-22 days □ 23-27 days □ Everyday
4. Have you tried to follow definite rules regarding your eating (for example, a calorie limit) in order to influence your shape or weight (whether or not you have succeeded)?	□ No days □ 1-5 days □ 6-12 days □ 13-15 days □ 16-22 days □ 23-27 days □ Everyday
5. Have you had a definite desire to have an empty stomach with the aim of influencing your shape or weight?	□ No days □ 1-5 days □ 6-12 days □ 13-15 days □ 16-22 days □ 23-27 days □ Everyday
6. Have you had a definite desire to have a totally flat stomach?	□ No days □ 1-5 days □ 6-12 days □ 13-15 days □ 16-22 days □ 23-27 days □ Everyday
7. Has thinking about food, eating or calories made it very difficult to concentrate on things you are interested in (for example, working, following a conversation, or reading)?	□ No days □ 1-5 days □ 6-12 days □ 13-15 days □ 16-22 days □ 23-27 days

	□ Everyday
8. Has thinking about shape or weight made it very difficult to concentrate on things you are interested in (for example, working, following a conversation, or reading)?	□ No days □ 1-5 days □ 6-12 days □ 13-15 days □ 16-22 days □ 23-27 days □ Everyday
9. Have you had a definite fear of losing control over eating?	□ No days □ 1-5 days □ 6-12 days □ 13-15 days □ 16-22 days □ 23-27 days □ Everyday
10. Have you had a definite fear that you might gain weight?	□ No days □ 1-5 days □ 6-12 days □ 13-15 days □ 16-22 days □ 23-27 days □ Everyday
11. Have you felt fat?	□ No days □ 1-5 days □ 6-12 days □ 13-15 days □ 16-22 days □ 23-27 days □ Everyday
12. Have you had a strong desire to lose weight?	□ No days □ 1-5 days □ 6-12 days □ 13-15 days □ 16-22 days □ 23-27 days □ Everyday
13. Over the past 28 days, how many times have you eaten what other people would regards as an unusually large amount of food (given the circumstances)?	_____ times
14. ... On how many of these times did you have a sense of having lost control over your eating (at the time you were eating)?	_____ times
15. Over the past 28 days, on how many DAYS have such episodes of overeating occurred (i.e. you have eaten an unusually large amount of food and have had a sense of loss of control at the time)?	_____ days
16. Over the past 28 days, how many times have you made yourself sick (vomit) as a means of controlling your shape or weight?	_____ times
17. Over the past 28 days, how many times have you taken laxatives as a means of controlling your shape or weight?	_____ times

18. Over the past 28 days, how many times have you exercised in a "driven" or "compulsive" way as a means of controlling your weight, shape or amount of fat, or to burn off calories?	_____ times
19. Over the past 28 days, on how many days have you eaten in secret (ie, furtively)? ... Do not count episodes of binge eating.	□ No days □ 1-5 days □ 6-12 days □ 13-15 days □ 16-22 days □ 23-27 days □ Everyday
20. On what proportion of the times that you have eaten have you felt guilty (felt that you've done wrong) because of its effect on your shape or weight? ... Do not count episodes of binge eating.	□ None of the times □ A few of the times □ Less than half □ Half of the times □ More than half □ Most of the time □ Every time
21. Over the past 28 days, how concerned have you been about other people seeing you eat? ... Do not count episodes of binge eating.	□ 0 Not at all □ 1 □ 2 Slightly □ 3 □ 4 Moderately □ 5 □ 6 Markedly
On how many over the past 28 days…	
22. Has your weight influenced how you think about (judge) yourself as a person?	□ 0 Not at all □ 1 □ 2 Slightly □ 3 □ 4 Moderately □ 5 □ 6 Markedly
23. Has your shape influenced how you think about (judge) yourself as a person?	□ 0 Not at all □ 1 □ 2 Slightly □ 3 □ 4 Moderately □ 5 □ 6 Markedly
24. How much would it have upset you if you had been asked to weigh yourself once a week (no more, or less, often) for the next four weeks?	□ 0 Not at all □ 1 □ 2 Slightly □ 3 □ 4 Moderately □ 5 □ 6 Markedly
25. How dissatisfied have you been with your weight?	□ 0 Not at all □ 1 □ 2 Slightly □ 3 □ 4 Moderately □ 5 □ 6 Markedly

26. How dissatisfied have you been with your shape?	□ 0 Not at all □ 1 □ 2 Slightly □ 3 □ 4 Moderately □ 5 □ 6 Markedly
27. How uncomfortable have you felt seeing your body (for example, seeing your shape in the mirror, in a shop window reflection, while undressing or taking a bath or shower)?	□ 0 Not at all □ 1 □ 2 Slightly □ 3 □ 4 Moderately □ 5 □ 6 Markedly
28. How uncomfortable have you felt about others seeing your shape or figure (for example, in communal changing rooms, when swimming, or wearing tight clothes)?	□ 0 Not at all □ 1 □ 2 Slightly □ 3 □ 4 Moderately □ 5 □ 6 Markedly

Note: Items are scored in four domains (restraint, eating concern, shape concern, weight concern) to give a global score

Restraint: (Sum of items 1-5) / 5

Eating Concern: (Sum of items 7, 9, 19, 20, 21) / 5

Shape Concern: (Sum of items 6, 8, 10, 11, 23, 26, 27, 28) / 8

Weight Concern: (Sum of items 8, 12, 22, 24, 25) / 5

Global Score: (Sum of items Restraint, Eating Concern, Shape Concern, Weight Concern) / 4

If score on EDE-Q >3 AND any of behavioural items 15-18 endorsed (>1), exclude and refer on to the InsideOut Institute clinical team for further assessment. Otherwise, participant may be included.

Appendix E – Digital Health Implementation Study Ethics Approval and Participant Information and Consent Form

THE UNIVERSITY OF SYDNEY

Research Integrity & Ethics Administration
HUMAN RESEARCH ETHICS COMMITTEE

Friday, 4 November 2022

Dr Stephanie Partridge
Health Sciences; Faculty of Medicine and Health
Email: stephanie.partridge@sydney.edu.au

Dear Stephanie,

The University of Sydney Human Research Ethics Committee (HREC) has considered your application.

I am pleased to inform you that after consideration of your response, your project has been approved.

Details of the approval are as follows:

Project No.:	**2022/778**
Project Title:	**Accelerating digital preventive health programs for adolescents: from research to implementation**
Authorised Personnel:	**Partridge Stephanie; Raeside Rebecca; Todd Allyson;**
Approval Period:	**04/11/2022 to 04/11/2026**
First Annual Report Due:	**04/11/2023**

Documents Approved:

Date Uploaded	Version Number	Document Name
26/10/2022	1	Email Invite_V1_190922_CLEAN
26/10/2022	1	Interview guide_V1_190922_CLEAN
26/10/2022	1	REDCap_Econsent

Condition/s of Approval

- Research must be conducted according to the approved proposal.
- An annual progress report must be submitted to the Ethics Office on or before the anniversary of approval and on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:
  - Serious or unexpected adverse events (which should be reported within 72 hours).
  - Unforeseen events that might affect continued ethical acceptability of the project.
- Any changes to the proposal must be approved prior to their implementation (except where an amendment is undertaken to eliminate *immediate* risk to participants).
- Personnel working on this project must be sufficiently qualified by education, training and experience for their role, or adequately supervised. Changes to personnel must be reported and approved.
- Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, as relevant to this project.
- Data and primary materials must be retained and stored in accordance with the relevant legislation and University guidelines.

Research Integrity & Ethics Administration
Research Portfolio
Level 3, F23 Administration Building
The University of Sydney
NSW 2006 Australia

T +61 2 9036 9161
E human.ethics@sydney.edu.au
W sydney.edu.au/ethics

ABN 15 211 513 464
CRICOS 00026A

THE UNIVERSITY OF SYDNEY

- Ethics approval is dependent upon ongoing compliance of the research with the *National Statement on Ethical Conduct in Human Research*, the *Australian Code for the Responsible Conduct of Research*, applicable legal requirements, and with University policies, procedures and governance requirements.
- The Ethics Office may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

This letter constitutes ethical approval only.

Please contact the Ethics Office should you require further information or clarification.

Sincerely,

[redacted]

Professor Michael Skilton
Chair
Health Review Committee (Low Risk)

The University of Sydney of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Human Research (2018) and the NHMRC's Australian Code for the Responsible Conduct of Research (2018)

Participant Information Sheet – Digital Health Implementation

Research Study: Accelerating digital preventative health programs for adolescents: from research to implementation

Dr Stephanie Partridge (Principal Investigator)
Senior Research Fellow in Engagement and Co-design Research Hub
School of Health Sciences, Faculty of Medicine and Health, University of Sydney.
Phone: +61 412 961 432 | Email: stephanie.partridge@sydney.edu.au

12. What is this study about?

We are conducting a research study to evaluate stakeholders' perspectives and level of support for adolescent digital health prevention interventions. We also aim to understand any barriers or enabling factors which could impact the implementation of such programs in current health care and community settings.

This study will help inform the development and implementation of future digital health prevention programs such as Health4Me, which is a healthy lifestyle text-message support program that is currently being co-designed by our research team with adolescents and stakeholders, and will be tested through a randomised controlled trial (RCT).

Taking part in this study is **voluntary.** Please read this sheet carefully. If you want more information or have any questions prior to participating, you can request a phone call with the study co-ordinator or research team at the University of Sydney.

13. Who is running the study?

The study is being carried out by the following researchers:

- Dr Stephanie Partridge (lead investigator)
- Ms Rebecca Raeside
- Ms Allyson Todd

This study is being funded by the Medical Research Future Fund (MRFF) and Primary Care Grant (MRFF2006315).

14. Who can take part in the study?

We are seeking stakeholders interested in digital health prevention programs for adolescents. This may include but is not limited to government (local, state, federal), health (local health districts, primary care networks), education (teachers and wellbeing staff), industry, non-government organisations (Youth Action, Aboriginal Community Controlled), youth services and community groups.

You may be eligible if you are:

- an adult (≥18 years)
- have an interest in adolescent populations
- willing to provide insights into digital health prevention programs with adolescents.

You have been invited to take part in this study because we have identified you as a potential stakeholder interested in adolescent health prevention programs.

15. What will the study involve for me?

If you decide to take part in this study, you will be asked to complete a brief online form and provide e-consent via Redcap, a university approved, secure online data capture system.

Once informed consent has been obtained, we will a schedule a time for an online interview through zoom. The interview will take up to 45 minutes. You will be asked a range of questions specifically related to your perspectives of the support and potential public health impact of digital health prevention interventions, including Health4Me, and potential pathways for future implementation.

Basic demographic data will be collected during the informed e-consent process via entry into the REDCap form. Demographic data includes age, gender, location, and ethnicity. We will also collect information regarding your current position, the organisation you work for, and how long you have been working at this organisation.

Interviews will be audio recorded only through Zoom for the purpose of data collection and transcription for analysis. The audio recording will be transcribed and will be available for review by participants upon request. All information will be de-identified prior to analysis and reporting.

16. Can I withdraw once I've started?

Being in this study is completely voluntary and you do not have to take part.

We do not anticipate your decision will affect your relationship with any staff members from the University of Sydney or other relevant stakeholders. All data collected will be confidential and all transcripts from audio recordings will be de-identified to protect anonymity.

If you decide to take part in the study and then change your mind you can withdraw by emailing the research team. If you decide to withdraw, we will not collect any more information from you. Any information that we have already collected will be kept in our study records and may be included in the study results. Audio recordings will be transcribed and de-identified, therefore your responses cannot be withdrawn.

If you take part in an interview you may refuse to answer any questions that you do not wish to answer.

17. Are there any risks or costs?

Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study.

18. Are there any benefits?

You will not receive any direct benefits from being in the study. However, your participation will help inform future development and implementation of digital health prevention programs and/or interventions for adolescents.

19. What will happen to information that is collected?

By providing your consent, you are agreeing to us collecting information about you for the purposes of this study.

Any information you provide us will be stored securely and we will only disclose identifiable information with your permission unless we are required by law to release information. All necessary steps will be taken to protect your confidentiality throughout the study. Any information obtained in connection with this research project that is identifiable will remain confidential.

Demographic data collected during the study will be stored on REDCap, a secure online system that is managed by the University of Sydney. All interview audio recordings and written transcripts will be de-identified and used for data analysis purposes only. They will be stored securely using our Research Data Store (RDS), which is a central network drive that allows secure storage of large datasets and files and complies with the University of Sydney's data security policies. Access to these files will be restricted to authorised researchers approved by the leading investigator.

All study related documents and data will be stored for a period of 5 years after publication of study results as per standard storage policies and stored on our RDS network drive. We are planning for the study findings to be published in peer-reviewed journals. You will not be individually identifiable in these publications. The results may also be presented at inter/national conferences and to any interested organisations (such as The NSW Office of Preventive Health).

We anticipate our findings will help inform future pathways in the implementation for adolescent digital health prevention interventions, including the Health4Me study.

20. Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. At the end of the study, we will provide a brief lay summary report of our findings.

21. What if I would like further information?

When you have read this information, the following researcher/s will be available to discuss it with you further and answer any questions you may have:

- Ms Rebecca Raeside, Research Associate Faculty of Medicine and Health, University of Sydney
  Email: rebecca.raeside@sydney.edu.au Phone: 0412 961 432

22. What if I have a complaint or any concerns?

The ethical aspects of this study have been approved by the Human Research Ethics Committee (HREC) of The University of Sydney 2022/778 according to the *National Statement on Ethical Conduct in Human Research (2007).*

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the University:

Human Ethics Manager
Email: human.ethics@sydney.edu.au
Phone: +61 2 8627 8176

Participant Consent Form – Digital Health Implementation

Research Study: Accelerating digital preventative health programs for adolescents: from research to implementation

Dr Stephanie Partridge (Principal Investigator)
Senior Research Fellow in Engagement and Co-design
Research Hub, School of Health Sciences, Faculty of Medicine and Health, University of Sydney.
Phone: +61 412 961 432 | Email: stephanie.partridge@sydney.edu.au

THE UNIVERSITY OF SYDNEY

Participant Name _____

I agree to take part in this research study. In giving my consent, I confirm that that:

- The details of my involvement have been explained to me, and I have been provided with a written Participant Information Statement to keep.
- I understand the purpose of the study is to investigate stakeholders' perspectives on the implementation of adolescent digital health prevention interventions.
- I acknowledge that the risks and benefits of participating in this study have been explained to me to my satisfaction.
- I understand that in this study I will be required to complete a brief form containing demographic data, and complete a 45-minute online interview, answering questions specifically related to my perspectives of the support and potential public health impact of a digital health prevention intervention, including Health4Me, and potential pathways for future implementation.
- I understand that my participation in the interview will be audio-recorded.
- I understand that my information may be used in future research to inform future development and implementation of adolescent digital health prevention interventions.
- I understand that being in this study is completely voluntary.
- I am assured that my decision to participate will not have any impact on my relationship with the research team or the University of Sydney.
- I understand that I am free to withdraw from this study at any time and that I can choose to withdraw any information I have already provided (unless the data has already been de-identified or published).
- I have been informed that the confidentiality of the information I provide will be protected and will only be used for purposes that I have agreed to. I understand that information identifying me will only be told to others with my permission, except as required by law.

- I understand that the results of this study may be published, and that publications will not contain my name or any identifiable information about me.

- I confirm the following:

  I consent to recordings (audio) Yes ☐ No ☐

  I would like to review my interview transcripts Yes ☐ No ☐

  I would like feedback on the overall results of this study Yes ☐ No ☐

  If you answered **yes**, please provide your preferred contact details (email/telephone/postal address):

  _____

  _____

  _____

  _____

- I understand that after I sign and return this consent form it will be retained by the researcher, and that I may request a copy at any time.

Participant Name _____

Signature _____

Date _____

Appendix F – Related Published Articles

Youth perspective on chronic disease prevention

Essay

Youth perspective on chronic disease prevention

Published Online April 29, 2022 https://doi.org/10.1016/S2352-4642(22)00131-6

For more on Youth Participatory Action Research principles see *New Dir Youth Dev* 2009; 2009: 19–34

For more on Youth Participatory Action Research processes see *Youth Soc* 2015; 47: 29–50

For guidelines on adolescent participation and civic engagement see https://www.unicef.org/documents/engaged-and-heard-guidelines-adolescent-participation-and-civic-engagement

Chronic diseases, climate change, mental health, and COVID-19 recovery are among the most serious challenges facing our generation, who account for one sixth of the global population. Yet, current approaches to chronic disease prevention are proving ineffective, with limited advocacy and leadership initiatives for young people to collaborate with researchers to improve chronic disease outcomes. Researchers are responsible for engaging with adolescents as active research partners and guarding against unconscious biases to shape actions that support adolescents to lead healthy lives.

Established in September, 2021, the Health Advisory Panel for Youth at the University of Sydney (HAPYUS) consists of 16 youth advisors aged 13–18 years from New South Wales in Australia, with a focus on chronic disease prevention. The youth advisory group is designed as a leadership initiative with the framework of collaboration informed by Youth Participatory Action Research principles, processes, and guidelines on adolescent participation and civic engagement. A key responsibility of our group is to provide advice to the research team on matters relating to adolescent chronic disease prevention.

In this Essay, we aim to provide first-hand insights on crucial issues that affect the wellbeing of young people living in Australia today. We have considered these issues within the context of the COVID-19 pandemic and climate change crisis, and examined their impact on the collective mental and physical health, as well as social engagement, of young people. Views were grounded in our lived experience and were gathered from the 16 HAPYUS members via three online group discussions and an online conversation thread between October, 2021, and February, 2022. We analysed and categorised the issues raised and have delineated these concerns as being of top priority: (1) inimical impact of the growing social media presence in the lives of young people, (2) incomplete or unbalanced nutritional intake, and (3) rise of physical inactivity. Collectively, we strongly feel that these issues are interconnected and interdependent, and should therefore be discussed in a multidimensional context with COVID-19, climate change, and mental health.

Our top concerns

Engaging with social media platforms is an everyday activity for many young people. Worryingly, social media platforms have been inundated with influencers who have the ability to promote or recommend certain products or services. As young people, we feel that influencers can use their profile to monetise the documentation of their lifestyles and exploit the vulnerability of younger audiences who idolise them. As such, the content viewed on social media has a profound effect on young people, with potentially more negative than positive effects on their physical and mental health. For example, influencers often promote unrealistic expectations of body image and diets that are not endorsed by health professionals, as well as unattainable lifestyles (eg, unaffordable goods and services). The popularity of social media influencers can be attributed to promotional techniques such as body-focused content, testimonials, or heavily staged and curated content. The rising popularity of photo-editing applications has increased the ease with which influencers are able to perfect their online brand and persona, often portraying unrealistic and false body images. This enables them to feed off the insecurities of younger audiences and disguises advertisements as environmentally and socially conscious—for example, by exploiting the youth's climate change concerns with so-called greenwashing (ie, misleading advertising to make products seem environmentally friendly). We acknowledge that there are ethical influencers and qualified professionals on social media who are actively seeking to promote healthy lifestyles, but they are the minority.

The relationship between body image and social media use by young people is a concern. Body image concerns might be emerging among our peers from the lack of diversity and representation of people from different ethnicities and cultures on social media. This lack of representation is forming a subculture identity of only certain body types within traditional gendered spaces. For males, this is a muscular aesthetic associated with gym and fitness lifestyles, while for females this is a lean aesthetic associated with nutrition, yoga, and mental wellness. The content relating to exercise and diet culture might be fuelling these aesthetic projections. Many social media platforms, such as Instagram, have algorithms to recommend content based on past activity, thus potentially exacerbating the lack of representation.

On social media we see frequent content by lifestyle influencers of new workouts, personal training, and quick 10 min fixes. These exercise suggestions, apart from being unrealistic for many, might cast expectations of the need for continuous exercise and result in obsessive exercise behaviours. Furthermore, social media enables a highly toxic and competitive culture. For example, some individuals seek to actively display the inequality of access to methods of physical activity, such as hiring personal instructors, to reflect their socioeconomic status. This can be highly detrimental to the wellbeing and physical activity levels of the wider youth community. It is important for health professionals on social media to not support this

status quo and dismantle this normative environment. We recommend health professionals consider gender and culturally tailored health messages on social media when trying to curb these faux healthy and highly toxic expectations of physical activity.

Arguably, the most physically detrimental aspects of social media are the excessive dieting culture promoted by influencers, leading to nutritional deficiencies and, in severe cases, eating disorders among youth. Diet culture is promoted to general youth audiences and to young aspiring athletes. Primarily, the common aesthetics that young people view on social media are often holistically and scientifically uninformed, enforcing heteronormative and culturally biased standards, thus proving not conducive to the collective mental and physical wellbeing of diverse young audiences.

Next, we recognise that the rising commercialisation of food corporations and fast food chains is being driven by enticing advertisements and sponsorships with influencers. Notably, promotional content on social media is disguised as an insight into celebrities' or influencers' lives, making this type of advertising less obvious for young viewers compared to conventional advertisements on television or print media. Increasing levels of poor nutrition among youth is partly a result of exposure to misleading advertising by fast food chains and influencers promoting certain lifestyles and brands that are often expensive. Issues related to unbalanced nutrition intake, such as the rise in obesity among youth globally, can be linked to the manipulative promotional tactics used by major fast food outlets, which lead young audiences to make uninformed choices to eat unhealthy and highly processed foods. Fast food is also conveniently priced at much lower costs than healthy foods, proving to be a more attractive choice for young people who might be financially disadvantaged. During the COVID-19 pandemic, takeout and home delivery have become popular options, and food corporations have benefitted from so-called COVID washing, a branding tactic that disguises manipulative advertising as philanthropy (eg, helping small businesses).

Another key issue for young people is misinformation of nutrition information, particularly on social media. For example, social media often promotes fresh and organic foods and supplements as healthy. Many young people might not be aware that the definition of organic is vague and does not guarantee anything about health, yet such advertising misleads young people to believe that these products are associated with health. Many organic foods are also expensive and inaccessible, which perpetuates the belief that having a healthy lifestyle is associated with wealth.

Recommendations

We recommend a two-tiered, multi-sector, and tailored approach to bolstering the health of young people. Tier 1 programmes should focus on creating awareness of social media use and addressing social media literacy. Topics could comprise evaluating social media for objective and well informed content versus misleading content, increasing knowledge on well balanced diet and physical activity, promoting awareness on mental health issues, and coping with consequences of the pandemic and climate change anxieties. Tier 2 builds on the acquired awareness and literacy with concrete guidance for implementation into daily life, such as affordable shopping lists and recipes for well balanced diets, suggestions for local opportunities for physical activity, and local mental health support. These programmes should be equally engaging and convincing as the plethora of promotional content on social media. To maximise accessibility, the programmes should be integrated within the school curriculum, conducted through educational seminars within schools, delivered by health and nutrition professionals in collaboration with young people. These interactive sessions would be of great benefit, especially to younger adolescents who are beginning to use social media. Facilitated discussions among peers can also provide insights into the evolution of youth interaction and experiences on social media. Additionally, such initiatives should be customised for specific age groups, genders, and cultures, providing them with the most relevant and appropriate information while addressing the financial barriers surrounding healthy diets. But most importantly, lawmakers and industry bodies should also be held accountable with stricter regulations for advertisements on TV, print media, and social media.

Researchers, policy makers, and governments need to consider the ramifications of COVID-19 restrictions and the long periods of lockdown on the ability for young people to access physical activity opportunities. During this time in Australia, sports and recreation centres, open public spaces, and sports grounds were closed, hindering opportunities for young people to be physically active and socially engaged. However, reduced physical activity in younger people could also be attributed to the near-omnipresence of digital media that facilitates prolonged screentime. Also, pre-pandemic costs associated with facilities such as gyms and indoor recreational spaces have led many young people to resort to internet trends led by influencers that often promote misinformed fitness regimens.

Interestingly, despite the subsequent lifting of lockdowns in Australia, the reduction of physical activity has partly remained, as young people became gradually more involved with online activities. Virtual communities provide an increasing substitute for sport and social activities, which will likely increase over coming years with the rise of the metaverse, an anticipated future three-dimensional iteration of the internet. School sport programmes have resumed, albeit encouraging face masks, but are not providing enough incentive for adequate physical activity throughout the week. Furthermore, competitive

For the 2021 UNICEF Australia Young Ambassador Report see https://www.unicef.org.au/our-work/unicef-in-emergencies/coronavirus-covid-19/childrens-voices

For more on chronic disease burden in adolescents see Articles *Lancet* 2019; 393: 1101–18

For more on adolescent health research agendas see *Front Public Health* 2021; 9: 789535

For more perspectives on adolescent voices in the chronic disease discourse see *Int J Non-Commun Dis* 2018; 3: 45–48

interschool events are now open to limited students upon expressions of interest, possibly reducing attendance of first-time participants due to increased exclusivity. High self-isolation rates due to spiking levels of COVID-19 infections among school-aged children (and teaching staff) after the reopening of schools pose an additional hurdle for returning to pre-pandemic levels of physical activity.

It is also important to acknowledge the socioeconomic, physical, and psychological barriers that the pandemic has exacerbated. To improve physical inactivity, governments and local community organisations must remove the barriers highlighted by their community and make it as easy as possible for young people to be physically active. Solutions could include opening recreational spaces for safe, physically distanced public use, along with free, tailored programmes, digital resources, and instruction sheets to support individuals and communities to participate in regular physical activity.

Conclusions and future directions

The top issues identified by HAPYUS are interconnected through the digitalisation and commercialisation of health and wellbeing on social media. These issues have been exacerbated by the COVID-19 pandemic and will continue to be amplified with ongoing global issues such as climate change. As a result, young people around the world face numerous barriers and adverse influences that pose harmful threats to their physical and mental health.

The overall health and wellbeing of adults have been shown to improve through awareness, education and prevention programmes, and targeted chronic disease management initiatives. However, similar initiatives for youth have not had the same desired impact, and young people need supportive digital and physical environments. The likely reasons for this, as highlighted above, are the susceptibility of youth to messages and trends promoted on social media, and government initiatives that do not consider the barriers that many young people face. Currently, governments spend more money on treating chronic diseases than preventing them, and prevention can start in youth and with youth. Thus, future programmes, initiatives, and strategies should account for youth-specific needs, such as diverse social media campaigns to effectively counteract the inimical consequences of influencer health trends that target young people. Critically, young people need to be actively engaged as collaborators to address these issues.

The top issues expressed above align with findings in national and international reports by young people that call for greater action by governments and decision makers. Despite concerted efforts by adolescent health researchers to understand and evaluate chronic disease prevention initiatives and policies, there has been no easing of the chronic disease burden since 1990, and many adolescent chronic disease risks factors have increased in prevalence. To date, research agendas for the prevention of chronic disease in adolescents are still almost entirely driven and implemented by adults. In 2017, at a community of practice focused on youth and chronic diseases, convened by the WHO Global Coordination Mechanism on the Prevention and Control of Noncommunicable Diseases, it was found the vast majority of adolescents believed that adolescent voices in the chronic disease discourse have been tokenistic and frequently dismissed. It is now well recognised that involving consumers can add value to health research and researchers have a right and responsibility to include consumers. The HAPYUS leadership initiative will work towards generating solutions to address these issues via a systems-based approach that is working towards fostering long-term collaborations between adolescents, researchers, and policy makers.

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See Online for appendix

Engaging adolescents in chronic disease prevention research: insights from researchers about establishing and facilitating a youth advisory group

Partridge *et al.*
Research Involvement and Engagement (2024) 10:29
https://doi.org/10.1186/s40900-024-00559-1

Research Involvement and Engagement

COMMENT Open Access

Engaging adolescents in chronic disease prevention research: insights from researchers about establishing and facilitating a youth advisory group

Stephanie R. Partridge[1,2*], Mariam Mandoh[1], Allyson Todd[1] and Rebecca Raeside[1,2]

Abstract

Our comment discusses our experience establishing a youth advisory group focused on chronic disease prevention research. The comment highlights three key learnings: the need for researchers to adapt their working style, the importance of redefining the power dynamics, and disrupting traditional research structures to align with co-researcher engagement models.

Keywords Youth, Adolescent, Participatory research, Advisory group, Consumer, Chronic disease prevention

Plain English Summary

In this comment, we share our insights from working with a youth advisory group in adolescent health research. Our comment supports our research paper on co-designing an online health study, "Health4Me." The youth advisors worked with us for a year, during which we also studied leadership and other outcomes.

Adolescent health is gaining worldwide attention. Health researchers see the value of working with young people on issues that affect them. To address this need, we formed the Health Advisory Panel for Youth at the University of Sydney. We motivated young people through building new skills and leadership training, rather than only focusing on improved health outcomes or health knowledge.

Here are our key lessons as researchers:

- Flexibility: We changed our approach to support online teamwork with young people, offered payment and worked around their schedules.
- Changing power dynamics: We empowered young people by engaging them in decisions and involved them in co-authoring papers and presentations.
- Challenging traditional structures: To support youth- as co-researchers, we used existing sources of funding and offered mentoring.

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In conclusion, we highlight practical ways of working with a youth advisory group in health research. Our teamwork led to a youth digital health program, published essays, and future research ideas. It is important for researchers to actively involve and support young people in shaping research that affects them.

Introduction

To complement the paper "Striking the right balance: co-designing the Health4Me healthy lifestyle digital health intervention with adolescents," [1] this comment reflects on our experience as researchers in establishing and managing a youth advisory group. Our youth advisory group supported our research projects, including the Health4Me intervention [2] for 12 months in 2021/22. We have also evaluated the process of establishing and facilitating the youth advisory group, which has been published elsewhere and includes the effect of participation in the youth advisory group on adolescents' leadership skills and perceptions related to chronic disease prevention research [3]. This comment extends and enriches our research findings by providing additional insights and reflections from our perspectives as researchers into the meaningful engagement of adolescents in health research that affects them.

Adolescent health and well-being are gaining attention globally with the "1.8 Billion Young People for Change Campaign" leading to the 2023 Global Forum for Adolescents [4]. Global organisations, including UNICEF, the World Health Organisation's Partnership for Maternal, Newborn and Child Health, and the United Nations Convention on the Rights of the Child, recognise the need for younger generations to be involved in issues that impact them. In the face of intergenerational challenges such as the chronic disease epidemic, it is increasingly important for researchers to engage meaningfully with adolescents in research decision-making. In a prevention research context, adolescent engagement is a developing area of investigation with limited pragmatic evidence for researchers [5]. Our systematic review found few studies in the chronic disease prevention field that meaningfully engaged adolescents as co-researchers, and fewer still evaluated their experiences in such a role [6].

To address the limited evidence for meaningfully engaging adolescents in chronic disease prevention research, we established the Health Advisory Panel for Youth at the University of Sydney (HAPYUS, pronounced 'Happy Us') in October 2021. In brief, of the 16 members, the mean age was 16 years, 50% of members identified as female, 25% resided in rural and remote areas and approximately 40% spoke a language other than English at home. We sought to recruit a diverse group of young people as our research extends beyond healthcare services research and into areas such as the food environment and digital landscape that are relevant to adolescent health and well-being broadly. To engage adolescents as co-researchers, we focused on process motivators, such as learning new skills and gaining experience, over outcome motivators, such as improved health outcomes or health knowledge. This comment highlights three key learnings from our experience as researchers coordinating our youth advisory group. We also provide a summary of dilemmas experienced in relation to each key learning and strategies we employed to overcome these challenges (Table 1).

Adapt working style

Firstly, we needed to adapt our working style to establish and foster our youth advisory group. The group operated mostly online as the adolescents were recruited from a wide geographical area in New South Wales, Australia. We provided monthly payments to youth advisors and allocated researcher time to support the group. Online meetings were scheduled outside school hours to accommodate the youth advisors' schedules. We envisioned most of the research collaboration occurring during the scheduled monthly meetings. However, we realised that youth advisor attendance at these meetings was limited, with only half of the group attending on average. To address this, we adopted a tiered engagement approach, offering multiple avenues for youth advisors to contribute comfortably and safely. We also secured funding to host one full day in-person workshop with the program designed by the youth advisors. Costs covered travel for members residing in rural or regional areas to attend.

We used Slack and linked collaborative tools such as Google Docs and Mural. As well, we made the meeting recordings available on Slack. As younger millennials and Gen Z researchers, ourselves, we are accustomed to using such online collaborative tools. However, our research training and institutional culture favours more traditional forms of communication and collaboration, such as email and file sharing on internal servers, which we recognise is important for research data privacy and security. We learned to be flexible and agile in our approach, while considering data privacy and security and adjust to group engagement changes and we recognise this approach is different to how our traditional research team operates. We recommend that researchers allocate a lead moderator to facilitate safe collaboration online and effectively communicate with the youth advisors and use tools that support collaborative research, while also adhering to

Table 1 Key learnings, dilemmas and strategies drawing on our experiences as researchers facilitating a youth advisory group

Key learnings	Experienced dilemmas	Strategies
Adapt working style	We faced the challenge of bringing 16 young people, who were previously unfamiliar with one another and cultivating a culture of mutual respect conducive to their roles as co-researchers. Acknowledging the casual nature of their involvement and their other commitments, we adapted our working style to ensure maximal engagement throughout the 12-month period	1. Employing a tiered approach to engagement, providing multiple avenues for participation during Zoom meetings, including verbal contributions, chat interactions, and the option to keep cameras on or off based on individual comfort levels
		2. Leveraging various features of Slack, such as group chats and private messaging by the moderator, to foster rapport among participants and stimulate engagement and collaboration
		3. Challenging traditional hierarchical communication structures (such as formal email communication) by fostering open dialogue and knowledge exchange on Slack, while maintaining a culture of respect and professionalism
		4. Striking a balance between the use of collaborative digital tools such Google Docs and Mural, ensuring the protection of sensitive research data through robust data privacy and security measures
Redefining power dynamics	We endeavoured to involve our youth advisors as co-researchers, extending the opportunity for co-authorship in scientific publications to those who met the authorship criteria. However, this presented a dilemma, as researchers, we have significant expertise in the scientific publication process, requiring us to mentor our youth advisors on navigating this complex process	1. Providing support and guidance to our youth advisors without imposing our own perspectives, ensuring their autonomy in shaping their contributions to the publications
		2. Assisting youth advisors in crafting statements to be included in published manuscripts (e.g. Boxes), thereby clearly delineating their contributions and interpretations of the findings
		3. Selecting journals with inclusive authorship policies that recognise the valuable input of young people or consumers, thereby fostering a supportive publishing environment
		4. Overcoming setbacks encountered with journals lacking such policies, which often categorised youth co-authors as research participants, necessitating additional ethics clearance and parental consent
		5. Advocating on behalf of our youth advisors to journals, emphasising their significant role and contributions to the research, thereby encouraging recognition and acceptance of their involvement
		6. Providing educational workshops or resources to youth advisors on the publication process to empower them with knowledge and skills

Table 1 (continued)

Key learnings	Experienced dilemmas	Strategies
Disrupting traditional research structures	In our efforts to operate our youth advisory group effectively and equitably, we needed to secure adequate funding and research capacity, a challenge we addressed by leveraging an existing grant. However, this solution presented a dilemma: how could we ensure the sustainability of our 12-month youth advisory model to support our future research endeavours?	1. Conducting a formal evaluation to gather evidence on the benefits of youth involvement in research, ensuring safe and effective engagement—a crucial consideration for researchers seeking to engage young people meaningfully 2. Promoting the involvement of youth advisors within our institution and beyond to ensure recognition of their valuable contributions, while advocating for the rights of young people to participate in matters that affect them directly 3. Implementing succession planning to address the issue of youth advisors aging out of their roles, ensuring continuity and providing opportunities for new youth advisors to engage in research initiatives, thereby fostering a dynamic and inclusive research environment 4. Creating a platform or network for former youth advisors to stay connected and continue contributing to research initiatives in advisory or mentorship roles, thereby harnessing their expertise and experience for the benefit of future projects

data security and privacy. A lead moderator can then allocate sufficient time to engage with group conversations, respond in a timely manner and help facilitate conversations and engagement, which helped reduce feelings of tokensim. Importantly, this allows youth advisors to build rapport with a key member of the research team. It is important to note, while we adapted our communication style, youth advisors also adapted their communication style as their initial approach was more aligned with how they might commonly communicate with teachers, whereas we were encouraging them to consider their role as co-researchers. We also recommend researchers evaluate their team's current working style and adapt elements that are not inclusive or do not foster effective collaboration with external collaborators, such as youth advisors.

Redefining power dynamics

Secondly, redefining the traditional power dynamic was crucial to engaging adolescents as co-researchers. Traditionally, adolescents are viewed as research participants rather than co-researchers. To shift this power gradient, we recruited them to include them in decision-making processes and value their lived experiences. To sustain a successful co-researcher partnership, researchers need to provide opportunities for adolescents to feel empowered within the scientific community, such as co-authorship on publications and reports and presentation opportunities. Our approach was guided by youth participatory action research (YPAR) principles [5], and we started by asking the youth advisors to identify their top issues related to chronic disease prevention. This task resulted in a published essay in a scientific journal [7] and presentations at national conferences (e.g., Australian Medical Association 2022 National conference) empowering youth advisors and demonstrating the value of their perspectives in the scientific community.

Disrupting traditional research structures

Finally, challenging the traditional research structures, the principles of YPAR encourage adolescent involvement in the entire research cycle, from deciding on research questions to undertaking systematic research. However, this poses a dilemma when resources such as researcher time and funding that are required for authentic youth engagement in research question development are typically not readily available through conventional scientific systems. Traditionally, researchers have already decided what to research before engaging with consumers and then applied for funding through submitting a grant proposal for peer review, which can take a significant amount of time. In our case, we had received funding to develop a youth-centred digital health program, Health4Me [2]. We had already decided what to research, however, to overcome some of the obstacles, we included sufficient budget to support a youth advisory group that would support the Health4Me project and could be leveraged to support future research projects. Through this strategy, we not only contributed to the grant's objectives—co-designing a youth-centred digital health program—but also delved into issues important to our youth advisors resulting in a co-authored publication on their top issues of concern for chronic disease prevention [7]. Additionally, we generated evidence regarding the impact of youth advisory groups through a formal evaluation of the group, focusing on their leadership and research skills, which has been published elsewhere [3]. Research timeframes, such as funding calls and research projects, which can be sporadic or have unforeseen delays, make it challenging to align with a 12-month youth advisory group. YPAR remains a cyclical process of learning and action, but changes are necessary within scientific systems to accommodate adolescents as co-researchers and modernise the system itself.

Conclusions

In conclusion, our comment sheds light on the practical considerations of establishing and facilitating a youth advisory group in the context of chronic disease prevention and digital health research. The three key learnings from our experience include the need for researchers to adapt their working style, redefine the traditional power dynamic between adolescents and researchers, and challenge conventional research structures to align with models of co-research, such as YPAR. Our successful collaboration between researchers and the youth advisors resulted in a youth designed digital health program, the publication of a scientific essay and future research ideas to explore. The global community recognises the importance of involving young people in issues that impact them. With growing attention on adolescent health and well-being, it is crucial for researchers to actively involve and support adolescents in making decisions about research that affects them.

Abbreviations

HAPYUS	Health Advisory Panel for Youth at the University of Sydney
YPAR	Youth participatory action research

Acknowledgements

The authors wish to thank members of HAPYUS, Dominik Mautner, Radhika Valanju, Imeelya Al Hadaya, Meera Barani, Alexi Cross, Emily McMahon, Bowen Ren, Dominique Rose, Aviral Sharda, Alexander Sinnett, Fulin Yan and the research evaluation team, Professor Julie Redfern, Professor Philayrath Phongsavan, Associate Professor Seema Mihrshahi, Dr Hoi Lin Cheng and Sara Wardak.

Author contributions
Conceptualisation, methodology and investigation (SRP, MM, AT, RR). Writing-original draft preparation (SRP). Writing- review and editing (SRP, MM, AT, RR). All authors have read and agreed to the published version of the manuscript.

Funding
HAPYUS was supported as part of a larger research project funded by the Australian Government Department of Health Medical Research Future Fund Primary Care Grant [2006315]. The Charles Perkins Centre funded the in-person HAYPUS workshop on 14th July 2022 at The University of Sydney. SRP is supported by a University of Sydney Horizon Fellowship and National Heart Foundation of Australia Future Leader Fellowship [Grant number: 106646]. RR is supported by a SOLVE-CHD PhD Scholarship and Supplementary Scholarship.

Availability of data and materials
All data generated or analysed during this study are included in this published article and its supplementary information files.

Declarations

Ethics approval and consent to participate
This article provides comment on a study that was performed in line with the principles of the Declaration of Helsinki. This project received ethical approval by the Human Research Ethics Committee (HREC) of the University of Sydney, date: 27.10.2021, approval No. 2021/749. Informed consent for the participants below 16 was obtained from the participants and this approach was approved by the University of Sydney Human Research Ethics Committee.

Consent for publication
The authors affirm that no identifying information was used in the preparation of this article.

Competing interests
The authors declare that they have no competing interests.

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Received: 8 January 2024 **Accepted:** 22 February 2024
Published online: 26 February 2024

References

1. Raeside R, Todd A, Wardak S, Gardner L, Champion KE, Kang M, et al. Striking the right balance: co-designing the Health4Me healthy lifestyle digital health intervention with adolescents. Res Involv Engagem. 2023;9(1):114.
2. Raeside R, Spielman K, Maguire S, Mihrshahi S, Steinbeck K, Kang M, et al. A healthy lifestyle text message intervention for adolescents: protocol for the Health4Me randomized controlled trial. BMC Public Health. 2022;22(1):1805.
3. Mandoh M, Raeside R, Todd A, Redfern J, Mihrshahi S, Cheng HL, et al. Evaluating the effect of a 12-month youth advisory group on adolescent's leadership skills and perceptions related to chronic disease prevention research: a mixed-methods study. BMC Public Health. 2023;23(1):2344.
4. Partnership for Maternal Newborn and Child Health (PMNCH). The global forum for adolescents and the 1.8 billion campaign. 2023. Available from: https://www.1point8b.org/.
5. Ozer EJ, Abraczinskas M, Duarte C, Mathur R, Ballard PJ, Gibbs L, et al. Youth participatory approaches and health equity: conceptualization and integrative review. Am J Community Psychol. 2020;66(3–4):267–78.
6. Mandoh M, Redfern J, Mihrshahi S, Cheng HL, Phongsavan P, Partridge SR. Shifting from tokenism to meaningful adolescent participation in research for obesity prevention: a systematic scoping review. Front Public Health. 2021;9:2133.
7. Valanju R, Barani M, Mautner D, Hadaya IA, Cross A, Gunawardana M, et al. Youth perspective on chronic disease prevention. Lancet Child Adolesc Health. 2022;6(7):456–8.

Publisher's Note

Mautner *et al. Research Involvement and Engagement* (2024) 10:56
https://doi.org/10.1186/s40900-024-00585-z

Research Involvement and Engagement

COMMENT Open Access

Experiences from youth advisors in chronic disease prevention research

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Abstract

Engaging young people in research is a promising approach to tackling issues like chronic disease prevention. Our involvement as youth advisors provided valuable experiences, including being at the forefront of change and learning to work within a research team. Furthermore, our experience provides greater insight and learnings for future youth engagement in research.

Plain English Summary

We are a group of 16 diverse young people from New South Wales, Australia, who are passionate about youth health. In 2021 and 2022, we formed the Health Advisory Panel for Youth at the University of Sydney (HAPYUS, pronounced 'Happy Us') working with researchers on projects to prevent chronic diseases in young people. We brainstormed health issues from our own experiences and other research and summarised them into the top three youth health concerns. From these, we helped develop and test programs to support healthy behaviours in young people. We used scientific and public events to present our findings. Finally, we presented our results in a research paper and through traditional and social media. One of the most rewarding experiences was the opportunity to be part of all stages of the research process of improving youth health especially because COVID-19 and social media changed the way we need to think about youth mental and physical health. We also learned how to work together amongst ourselves as young people and within a research team. We hope that other young people can learn from our experiences and feel inspired to become active contributors in projects for meaningful change in the lives of young people.

Keywords Youth, Adolescent, Participatory research, Advisory group, Consumer, Chronic disease prevention

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Comment

Chronic diseases in young people are rising at an alarming rate calling for research into possible preventative measures [1]. There is growing evidence that health outcomes in young people may be improved through interventions that are targeted and youth-specific, e.g., using youth-relevant language, technology, and motivational cues [2–5]. One promising approach is by including young people in appropriate research decision-making using a framework of collaboration informed by the Youth Participatory Action Research principles and processes and guidelines on adolescent participation and civic engagement [6–8]. As a result, the pilot Health Advisory Panel for Youth at the University of Sydney (HAPYUS, pronounced 'Happy Us') was established to enhance collaborations between young people and researchers as a vital step in improving current efforts in public health [9, 10]. We, the group of young people from HAPYUS, are co-authors on the paper "Striking the right balance: co-designing the Health4Me healthy lifestyle digital health intervention with adolescents," [8] published in December 2023. We also participated in a formal evaluation of the youth advisory group, which has been published elsewhere and includes demographic details of our group and details regarding the process of establishing and facilitating the group [9]. We have written this comment as follow-up to the already published papers to provide a unique and different perspective as young people. As young people, we are often not meaningfully included in scientific discourse about research that affects us. Thus, we aim to provide additional learnings for future youth engagement in research.

Selected by researchers of the University of Sydney via an application process, HAPYUS started as a group of 16 young people aged between 13 and 18 years from across New South Wales Australia from diverse backgrounds and with different experiences, who had never met before but shared a passion for youth advocacy and youth health, and who were willing to commit time and effort into a shared endeavour despite the ongoing pandemic at the time. During 2021/22, we engaged in discussion through a hybrid model of virtual meetings, online chat discussions and in-person workshops to tackle the issues of improving youth's physical and mental health. Our research and development process involved the following stages:

1. Conceptualising: brainstorming top health issues by drawing from young people's lived experiences as well as relevant research literature.
2. Refining: distilling the broad range of issues into the top three health concerns and research questions [11].
3. Prototyping: shaping initiatives and digital programs to support healthy behaviours in young people such as the "Health4Me" program [8, 12] and "YES!" Project (unpublished).
4. Testing: scaling up of prototypes for use by adolescents; receiving feedback from participants as well as youth advisors.
5. Communicating: presenting our perspectives and recommendation strategies through a written report, media releases, and further distribution via social media platforms.

Working through a structured process enabled us as youth advisors to learn about various aspects of research and youth engagement. Guided by the three principles of Youth Participatory Action Research [13–15] we (a) worked inquiry-based, tackling questions that were grounded in our lived experiences, (b) participated in all steps of the research process and (c) aimed to change knowledge and practices to improve the lives of youth by active intervention. Furthermore, we gained valuable insights into collaboration and communication in different forms. While initial workshops and meetings were led by researchers, the project steps were subsequently divided into smaller tasks and worked on individually or in smaller groups, which self-selected based on interest or experience. Working remotely, we realised that to collaborate effectively we needed access to shared technology, efficient file-sharing, the possibility of co-authoring, video conferencing without time limits, and making use of our different strengths and experiences. As we mainly worked self-driven and asynchronous at different times of the day and at different days, we determined that feedback and planning is crucial as well as the ability to build on the work of others while also seamlessly moving in-between different tasks and different projects and research teams. Through continuous feedback amongst each other as well as regular update meetings with researchers we enhanced our efficiency as a team as well as our personal growth. We identified three main experiences as most valuable to us throughout the course of our roles at HAPYUS, (1) being at the forefront of change, (2) learning to work within a research team, and (3) communicating data and perspectives.

Being at the forefront of change

As youth advisors, we share a sense of scientific curiosity and proactive engagement for health issues. Working with researchers from the Faculty of Medicine and Health at The University of Sydney enabled our group to be at the forefront of a rapidly evolving landscape of youth and adolescent preventive health research. We mainly focused on prevention efforts for chronic diseases such as cardiovascular diseases, type 2 diabetes and

obesity. Risk factors for these chronic diseases are often established in younger years, but prevention programs are mostly geared towards adults [16, 17]. In past generations, this approach might to some extent have been effective for younger people as well, as most age groups were exposed to similar communication channels, such as print, TV, billboards, or radio. However, with the rise of digital technology, social media, and personalised algorithms, many young people are now using different media than adults and 'traditional' prevention campaigns often do no longer reach younger age groups [18]. Youth engagement provides an avenue for researchers to collaborate directly with young people as members of the research team to conduct prevention research that is relevant to young people, using their preferred platforms. Those efforts seem especially relevant for preventable chronic diseases, as they pay a triple dividend by improving the lives of young people in the present, but also by providing them with a chance to lead a full adult life and subsequently giving rise to future generations.

Having identified three top concerns regarding chronic disease prevention in young people (i.e., social media's inimical impact on young people, unbalanced nutritional intake, and rise of physical inactivity) [11], we realised that these issues were dynamically changing based on the multidimensional context of COVID-19. This also included growing concerns for youth mental health with research suggesting a worsening of social isolation and psychological distress [19, 20], particularly associated with depression and anxiety [21, 22]. We understood that existing concepts about youth mental and physical health needed modification due to restrictions posed by the pandemic with not only disruptions to daily life, but also loss of support and services outside the family home leading to an increase in demand of services but simultaneously to constraints on the supply of those services [21–24]. On the other hand, new opportunities in service delivery emerged with the rising prevalence of social media that could be employed as alternative avenue of information and service delivery. The challenge was to create content that is relevant for the target audience. Being part of the same age bracket and with diverse and lived experiences our group was uniquely positioned to reach that target group through content creation of topics on chronic disease prevention. Discussing these concerns with researchers gave us the opportunity to represent the perspective of young people whilst also collaborating on new ways to overcome adolescent health issues, such as with the following projects and our reflections presented in Table 1.

Working within a research team

Despite geographic distance and COVID-19 restrictions, we were able to collaborate within our advisory team as well as with the team of researchers via online platforms such as Slack and Mural. The online environment allowed us to contribute equally independent of location and scheduling constraints. Shared access and building on each other's work meant being open and tolerant to constantly changing and evolving files and accept some loss of 'ownership' of individual contributions as projects evolved, but this evolved into shared ownership which was empowering. Working online also meant missing out on some shared experiences beyond the immediate

Table 1 Reflections on our involvement in adolescent health research projects

Project	Our reflections
Health4Me: digital health program to support young people's nutrition and physical well-being	By considering the ever-growing presence of technology in the daily lives of youth, we recognised text messaging as a high yield avenue for reaching out to younger audiences. Using the identified top health issues, we collectively brainstormed text messages that would remind and encourage young people to complete short, health-related activities, to help improve their physical and mental health. By providing our input, we were able to construct text messages that we as young people felt would resonate with other teenagers and at the same time achieve potentially health-relevant modifications in behaviour. This represents a significant shift in conventional adolescent health research approaches by increasing youth involvement in the creation of meaningful health tools ("by youth, for youth"). The study protocol and co-design process for this study have been published and our contribution is acknowledged [8, 12].
YES! Project Youth Engagement Study	Another oftentimes limiting aspect of current research regarding youth health is lack of feedback from young people on data collected about them. Thus, our collaboration on this project emphasised the analysis of youth responses, such as real-time viewpoints from youth on questions about civic engagement at all levels. Additional opportunities for us were also provided in shadowing focus groups by scribing key issues explored by participants. Thus, this project emphasised youth involvement at every stage through a multitude of roles for young people, from collaborators to participants, to effectively improve the feedback loop that shapes our understanding of perceptions of youth engagement. This project is ongoing, and we look forward to collaborating on the scientific manuscript.
Youth Advisory Group (YAG) Evaluation Study	Thirteen members of HAPYUS participated in an evaluation study that consisted of completing a written and verbal questionnaire about our experiences as part of HAPYUS in intervals of 6 months [9]. This is an innovative approach to embed youth feedback into research studying the impact on youth collaborators, who are designing health tools, rather than studying the target group for the health tools (which is young people using the health applications). Additionally, reflecting on our communication, teamwork skills and confidence, most of us agreed that our research engagement helped us learn more about our holistic development as individuals.

tasks at hand. On the other hand, our mutual learning and increased efficiency meant we improved our work on many levels. The diversity of our group, both culturally and geographically, proved valuable in identifying the complex interactions leading to chronic disease in young people including barriers to healthy living. We were able to draw on our lived experience and share these experiences with the group, if we felt comfortable. For example, group members from urban areas reported in general better access to health services, whereas some group members from rural communities had the advantage of a broader network of family and neighbours mitigating the effects of sudden loss of social contacts during the pandemic. Also, we discussed how ethnicity and gender stereotypes played a role in reduced sport participation and how health information was communicated on social media. To effectively delegate responsibilities based on strengths and interests, we divided ourselves into working teams and subsequently updated other working teams through a regular feedback system.

Within the HAPYUS advisory group, the team of co-chairs worked together on collating the experiences of all members culminating in a report and media releases, a process that involved regular regrouping. We also formed teams for consulting with the various state and federal parliamentarians, speaking at the Australian Medical Association conference, and for drafting policy briefings. As a team with sixteen members, it was crucial that we distributed opportunities equally amongst ourselves to allow everyone to be involved in collaborations on both a small and large scale.

The most valuable aspect of working within the Youth Participatory Action Research framework was the guidance of researchers which motivated us for constant improvement using feedback in areas of delegation and time management to ensure we worked together effectively. Learning those skills will also be important for the future, as in a rapidly changing workforce, online collaboration is expected to be an essential skill.

Communicating data and perspectives

Traditionally, young people have been distanced from both readership of academic literature (due to jargon that may be difficult for readers from non-research backgrounds and with limited awareness of relevant materials available regarding youth health issues) as well as co-authorship of academic literature (as research was considered strictly a domain of adult experts). HAPYUS represented to us as youth advisors an innovative path of youth involvement allowing us to use our own voice. To avoid tokenistic youth participation, we felt the need to create an authentic account that would be accessible to younger audiences throughout the world. Our group co-authored a perspective essay about the evolution of youth health contextualised by the pandemic, which was published by The Lancet Child and Adolescent Health as "Youth perspective on chronic disease prevention" [11]. As some of the youngest co-authors to be published in The Lancet, we achieved two important goals:

- Bridging the gap between youth and academia.
- Presenting our concerns through synthesising research evidence and perspectives, leading to increased awareness of chronic disease in young people and potentially novel approaches for solutions.

Through the ensuing interest by national level media, we had an opportunity for further public discussions, such as through The Sydney Morning Herald (national Australian newspaper) and Sunrise (national Australian breakfast television program), raising awareness amongst the wider scientific community but also the public including younger audiences. Other opportunities included presenting at the Australian Medical Association Conference (the peak professional body for medical doctors in Australia), and discussions with policy advisors of the state and federal Government.

Data communication is becoming an increasingly sought-after skill and we as youth advisors greatly benefited from working through various modes of communication, from article writing to interviews and conference presentations. Through these opportunities, we gained invaluable experiences, but most importantly, we hopefully contributed in a meaningful way to youth health research and better health outcomes for young people.

Conclusions

In conclusion, our involvement in the HAPYUS has been influential in advancing youth engagement in chronic disease prevention research. Based on the principles of Youth Participatory Action Research we navigated dynamic health challenges, improved our collaboration skills, and bridged the gap between youth and researchers through effective communication. Our experiences offer valuable insights for future youth involvement in addressing chronic disease prevention research.

Abbreviations

HAPYUS Health Advisory Panel for Youth at the University of Sydney

Acknowledgements

The authors wish to thank the other HAPYUS members who contributed to various activities over the 12-month term and the guest speakers who attended our meetings to share their research. We also thank all members of the research team, Dr Stephanie Partridge (who proofread this comment and provided guidance in its preparation), Mariam Mandoh, Rebecca Raeside, Professor Julie Redfern, Professor Philayrath Phongsavan, Associate Professor Seema Mihrshahi and Dr Hoi Lin Cheng.

Author contributions
Conceptualisation, methodology and investigation (DM, RV, IAH, MB, AC, EM, BR, DR, AS, AS, FY, SW). Writing- original draft preparation (DM, RV, SW). Writing- review and editing (DM, RV, IAH, MB, AC, EM, BR, DR, AS, AS, FY, SW). All authors have read and agreed to the published version of the manuscript.

Funding
HAPYUS is supported as part of a larger research project funded by the Australian Government Department of Health Medical Research Future Fund Primary Care Grant [2006315] and via a University of Sydney Horizon Fellowship and National Heart Foundation of Australia Future Leader Fellowship [Grant number: 106646] awarded to Dr Stephanie Partridge. The Charles Perkins Centre funded the in-person HAPYUS workshop on 14th July 2022 at The University of Sydney.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This article provides comment on a study that was performed in line with the principles of the Declaration of Helsinki. This project received ethical approval by the Human Research Ethics Committee (HREC) of the University of Sydney, date: 27.10.2021, approval No. 2021/749. Informed consent for the participants below 16 was obtained from the participants and this approach was approved by the University of Sydney Human Research Ethics Committee.

Consent for publication
All authors have provided consent for publication. No individual identifying information was used in the preparation of this article.

Competing interests
The authors declare no competing interests.

Received: 8 January 2024 / Accepted: 15 May 2024
Published online: 07 June 2024

References

1. Biswas T, Townsend N, Huda MM, Maravilla J, Begum T, Pervin S, et al. Prevalence of multiple non-communicable diseases risk factors among adolescents in 140 countries: a population-based study. eClinicalMedicine. 2022;52. https://doi.org/10.1016/j.eclinm.2022.101591.
2. Mandoh M, Redfern J, Mihrshahi S, Cheng HL, Phongsavan P, Partridge SR. Shifting from Tokenism to Meaningful Adolescent Participation in Research for Obesity Prevention: a systematic scoping review. Front Public Health. 2021;9(2133). https://doi.org/10.3389/fpubh.2021.789535.
3. Zieve GG, Richardson LP, Katzman K, Spielvogle H, Whitehouse S, McCarty CA. Adolescents' perspectives on personalized E-Feedback in the context of Health Risk Behavior Screening for Primary Care: qualitative study. J Med Internet Res. 2017;19(7):e261. https://doi.org/10.2196/jmir.7474.
4. Whitehouse SR, Lam P-Y, Balka E, McLellan S, Deevska M, Penn D, et al. Co-creation with TickiT: Designing and evaluating a clinical eHealth platform for Youth. JMIR Res Protoc. 2013;2(2):e42. https://doi.org/10.2196/resprot.2865.
5. Raeside R, Jia SS, Todd A, Hyun K, Singleton A, Gardner LA, et al. Are Digital Health interventions that target lifestyle risk behaviors effective for Improving Mental Health and Wellbeing in adolescents? A systematic review with Meta-analyses. Adolesc Res Rev. 2023. https://doi.org/10.1007/s40894-023-00224-w.
6. Anyon Y, Bender K, Kennedy H, Dechants J. A Systematic Review of Youth Participatory Action Research (YPAR) in the United States: methodologies, Youth outcomes, and future directions. Health Educ Behav. 2018;45(6):865–78. https://doi.org/10.1177/1090198118769357. Epub 2018/05/12.
7. UNICEF. Engaged and heard: Gudelines on adolescent participation and civic engagement. New York, USA: 2020.
8. Raeside R, Todd A, Wardak S, Gardner L, Champion KE, Kang M, et al. Striking the right balance: co-designing the Health4Me healthy lifestyle digital health intervention with adolescents. Res Involv Engagem. 2023;9(1):114. https://doi.org/10.1186/s40900-023-00524-4.
9. Mandoh M, Raeside R, Todd A, Redfern J, Mihrshahi S, Cheng HL, et al. Evaluating the effect of a 12-month youth advisory group on adolescent's leadership skills and perceptions related to chronic disease prevention research: a mixed-methods study. BMC Public Health. 2023;23(1):2344. https://doi.org/10.1186/s12889-023-17283-2.
10. Partridge SR, Mandoh M, Todd A, Raeside R. Engaging adolescents in chronic disease prevention research: insights from researchers about establishing and facilitating a youth advisory group. Res Involv Engagem. 2024;10(1):29. https://doi.org/10.1186/s40900-024-00559-1.
11. Valanju R, Barani M, Mautner D, Hadaya IA, Cross A, Gunawardana M, et al. Youth perspective on chronic disease prevention. Lancet Child Adolesc Health. 2022;6(7):456–8. https://doi.org/10.1016/S2352-4642(22)00131-6. PubMed PMID: WOS:000836588500010.
12. Raeside R, Spielman K, Maguire S, Mihrshahi S, Steinbeck K, Kang M, et al. A healthy lifestyle text message intervention for adolescents: protocol for the Health4Me randomized controlled trial. BMC Public Health. 2022;22(1):1805. https://doi.org/10.1186/s12889-022-14183-9. Epub 20220923.
13. Branquinho C, Tomé G, Grothausen T, Gaspar de Matos M. Community-based Youth Participatory Action Research studies with a focus on youth health and well-being: a systematic review. J Community Psychol. 2020;48(5):1301–15. https://doi.org/10.1002/jcop.22320.
14. Njelesani J, Hunleth J. Youth participatory research evidence to inform health policy: a systematic review protocol. BMJ open. 2020;10(8):e036522. Epub 20200811. doi: 10.1136/bmjopen-2019-036522. PubMed PMID: 32784255; PubMed Central PMCID: PMC7418675.
15. Sanchez S, Thorburn R, Rea M, Kaufman P, Schwartz R, Selby P, et al. A systematic review of theories, models and frameworks used for youth engagement in health research. Health Expect. 2024;27(1):e13975. https://doi.org/10.1111/hex.13975.
16. Howse E, Crosland P, Rychetnik L, Wilson A. The value of prevention: an evidence check rapid review brokered by the Sax Institute for the Centre for Population Health. Sydney, Australia: NSW Ministry of Health; 2021.
17. Pikora T, Christian H, Trapp G. K. V. Chronic disease prevention interventions in children and young adults: A rapid review prepared for the Australian Government Department of Health on behalf of The Australian Prevention Partnership Centre. Sydney, Australia: 2016.
18. O'Reilly M, Dogra N, Hughes J, Reilly P, George R, Whiteman N. Potential of social media in promoting mental health in adolescents. Health Promot Int. 2019;34(5):981–91. https://doi.org/10.1093/heapro/day056. PubMed PMID: 30060043; PubMed Central PMCID: PMC6904320.
19. Australian Institute of Health and Welfare. COVID-19 and the impact on young people Canberra: AIHW; 2021 [cited 2024 02-04-2024]. https://www.aihw.gov.au/reports/children-youth/covid-19-and-young-people.
20. Young Minds. The impact of Covid-19 on young people with mental health needs United Kingdom: Young Minds,; 2021 [cited 2024 02-04-2024]. https://www.youngminds.org.uk/about-us/reports-and-impact/coronavirus-impact-on-young-people-with-mental-health-needs/#main-content.
21. Thorisdottir IE, Agustsson G, Oskarsdottir SY, Kristjansson AL, Asgeirsdottir BB, Sigfusdottir ID, et al. Effect of the COVID-19 pandemic on adolescent mental health and substance use up to March, 2022, in Iceland: a repeated, cross-sectional, population-based study. Lancet Child Adolesc Health. 2023;7(5):347–57. https://doi.org/10.1016/S2352-4642(23)00022-6.
22. Bell IH, Nicholas J, Broomhall A, Bailey E, Bendall S, Boland A, et al. The impact of COVID-19 on youth mental health: a mixed methods survey. Psychiatry Res. 2023;321:115082. https://doi.org/10.1016/j.psychres.2023.115082. Epub 20230128.
23. World Economic Forum. How technology can help to manage COVID-19's mental health fallout 2020 [cited 2024 02-04-2024]. https://www.weforum.org/agenda/2020/08/covid-19-mental-health-telehealth/.
24. Piper S, Davenport TA, LaMonica H, Ottavio A, Iorfino F, Cheng VWS, et al. Implementing a digital health model of care in Australian youth mental health services: protocol for impact evaluation. BMC Health Serv Res. 2021;21(1):452. https://doi.org/10.1186/s12913-021-06394-4.

Publisher's Note

Feasibility and Acceptability of Chatbots for Nutrition and Physical Activity Health Promotion Among Adolescents: Systematic Scoping Review With Adolescent Consultation

Review

Feasibility and Acceptability of Chatbots for Nutrition and Physical Activity Health Promotion Among Adolescents: Systematic Scoping Review With Adolescent Consultation

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Abstract

Background: Reducing lifestyle risk behaviors among adolescents depends on access to age-appropriate health promotion information. Chatbots—computer programs designed to simulate conversations with human users—have the potential to deliver health information to adolescents to improve their lifestyle behaviors and support behavior change, but research on the feasibility and acceptability of chatbots in the adolescent population is unknown.

Objective: This systematic scoping review aims to evaluate the feasibility and acceptability of chatbots in nutrition and physical activity interventions among adolescents. A secondary aim is to consult adolescents to identify features of chatbots that are acceptable and feasible.

Methods: We searched 6 electronic databases from March to April 2022 (MEDLINE, Embase, Joanna Briggs Institute, the Cumulative Index to Nursing and Allied Health, the Association for Computing Machinery library, and the IT database Institute of Electrical and Electronics Engineers). Peer-reviewed studies were included that were conducted in the adolescent population (10-19 years old) without any chronic disease, except obesity or type 2 diabetes, and assessed chatbots used nutrition or physical activity interventions or both that encouraged individuals to meet dietary or physical activity guidelines and support positive behavior change. Studies were screened by 2 independent reviewers, with any queries resolved by a third reviewer. Data were extracted into tables and collated in a narrative summary. Gray literature searches were also undertaken. Results of the scoping review were presented to a diverse youth advisory group (N=16, 13-18 years old) to gain insights into this topic beyond what is published in the literature.

Results: The search identified 5558 papers, with 5 (0.1%) studies describing 5 chatbots meeting the inclusion criteria. The 5 chatbots were supported by mobile apps using a combination of the following features: personalized feedback, conversational agents, gamification, and monitoring of behavior change. Of the 5 studies, 2 (40.0%) studies focused on nutrition, 2 (40.0%) studies focused on physical activity, and 1 (20.0%) focused on both nutrition and physical activity. Feasibility and acceptability varied across the 5 studies, with usage rates above 50% in 3 (60.0%) studies. In addition, 3 (60.0%) studies reported health-related outcomes, with only 1 (20.0%) study showing promising effects of the intervention. Adolescents presented novel concerns around the use of chatbots in nutrition and physical activity interventions, including ethical concerns and the use of false or misleading information.

Conclusions: Limited research is available on chatbots in adolescent nutrition and physical activity interventions, finding insufficient evidence on the acceptability and feasibility of chatbots in the adolescent population. Similarly, adolescent consultation identified issues in the design features that have not been mentioned in the published literature. Therefore, chatbot codesign with adolescents may help ensure that such technology is feasible and acceptable to an adolescent population.

(JMIR Hum Factors 2023;10:e43227) doi: 10.2196/43227

KEYWORDS

chatbot; artificial intelligence; text message; adolescent nutrition; physical activity; health promotion

Introduction

Adolescents, aged 10-19 years, as defined by the World Health Organization (WHO), are a unique age group, who begin to develop independent lifestyle habits that they carry into adulthood [1]. Concerningly, the prevalence of overweight and obesity among adolescents is increasing worldwide. In 2016, more than 31 million children and adolescents aged 5-19 years were reported as overweight or obese [1]. Overweight and obesity in adolescence are associated with poorer health outcomes in adulthood, including cardiovascular disease and type 2 diabetes [2]. Therefore, intervening early in the life course is critical to prevent the future burden of chronic disease and comorbidities [3,4]. Regular physical activity and optimal nutrition are fundamental in preventing and assisting those with overweight and obesity to return to a healthy weight. Worldwide, more than 80% of adolescents do not meet the recommended levels of physical activity or sedentary behavior guidelines [4]. Since the COVID-19 pandemic began, research has reported increased screen time being associated with weight gain among adolescents [2]. Additionally, most adolescents fail to meet WHO's guidelines on daily fruit and vegetable intake [5]. The overconsumption of nutrient-poor, ultraprocessed foods and sugar-sweetened beverages is further contributing to the rising rates of overweight and obesity. Simultaneously, malnutrition, micronutrient deficiencies, and food insecurity continue to persist among adolescents worldwide [6]. Adolescents need support to improve physical activity and nutrition behaviors, which in turn will minimize the growing rate of adolescents with overweight and obesity worldwide.

Digital health interventions, such as mobile apps, text messaging, and gamification, show promise for improving the health of adolescents through targeting physical activity and dietary behaviors [7,8]. Nearly 70% of adolescents in high-income countries have a smartphone and are frequently online [9]. Mobile-based interventions are relatively low cost, accessible, and widely acceptable among adolescents [10]. Gamification is the implementation of game design elements in real-world contexts for nongaming purposes [11] and has been found to be effective in improving physical activity levels, fruit and vegetable intake, and nutrition knowledge in adolescents [12,13]. For example, the popular online game Pokémon Go has been found to promote physical activity [7,14]. Mobile apps may assist in improving adolescents' health with a plethora of apps available. A review by Schoeppe et al [15] found that currently available mobile apps that promote physical activity and nutrition have moderate quality and use a range of behavior change techniques, such as encouragement, performance feedback, and gamification. However, there is limited knowledge of user engagement [15]. A randomized controlled trial, conducted in 14 secondary schools in Australia, evaluated the influence of a mobile app to promote physical activity in adolescents and found that half of the participants were influenced by the "push-prompt" message reminder to be active, reduce sweetened beverage consumption, and reduce screen time [16]. Further, the use of semipersonalized text messaging has been found to be a feasible and acceptable strategy to engage adolescents to promote healthy behaviors [17]. Incorporating gamification and personalized feedback may help improve engagement for young people in digital health interventions [13]. As technology continues to evolve, it is important to evaluate emerging features to help improve and sustain diet and physical activity behaviors among adolescents [7,18].

Artificial intelligence (AI) is a rapidly developing technical science being applied to the health care field [8,19]. It is commonly used in precision medicine, using machine learning, which involves training models with data [19]. The use of natural language processing (NLP) allows AI to communicate using humanlike language, as well as to extract and construct information from social media and medical documents [8]. AI items, such as Apple Siri and Google Assistant, are becoming increasingly popular among the public to answer health-related questions [20,21]. Chatbots are an emerging software application designed for text-based conversation. They can search for information from the internet or a database to respond to users' inquiries and personalize communication with humans [22]. Chatbots can be designed with or without AI. Those without AI cannot learn and adapt and often have predetermined responses based on the question asked by the user. However, AI chatbots are trained to have humanlike conversations using NLP. Therefore, there is potential for the use of chatbots as a digital health intervention to improve nutrition and physical activity behaviors across the life course. There is current evidence of chatbots promoting physical activity in the adult population, which is encouraging, but further research is needed to support these findings [23]. A systematic review investigating the use of chatbots to improve physical activity and nutrition across all age groups found no studies specifically targeting adolescents [23]. Chew's [24] recent scoping review of chatbots used to promote weight loss across all age groups also found the same gap in knowledge and highlighted the importance of using age-appropriate design features to enhance engagement for adolescents There is potential for this cost-effective and highly accessible technology to deliver health information to young people to improve their nutrition and physical activity behaviors [25]. However, there is limited research on the feasibility and acceptability of chatbots in the adolescent population [23]. This systematic scoping review aims to evaluate findings from peer-reviewed, published studies to understand the feasibility and acceptability of chatbots to promote nutrition and physical activity in adolescents. A secondary aim is to identify design features of chatbots that would be acceptable and feasible with an established youth advisory group.

Methods

Study Design

A scoping review was determined to be the most suitable method to synthesize data to identify knowledge gaps and look broadly at the existing literature [26]. The systematic scoping review methodology was informed by the 6-stage methodological framework outlined by Arksey and O'Malley [27] and the Joanna Briggs Institute guidelines for scoping reviews [28]. The review was reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping reviews (PRISMA-ScR) [29]. The research questions were formulated by the research team, along with the eligibility criteria for including relevant studies. Next, studies were selected based on the predefined eligibility criteria, and relevant data from the included studies were extracted. Following data extraction, results were collated and summarized narratively.

Eligibility Criteria

To be included, peer-reviewed research studies must have (1) been conducted in the adolescent population, defined according to WHO as the second decade of life (10-19 years); (2) participants without a chronic disease, except obesity or type 2 diabetes; (3) assessed the feasibility and acceptability of chatbots used for nutrition or physical activity interventions or both that encourage individuals to meet dietary or physical activity guidelines and support positive behavior change; (4) been conducted in 2010 and beyond (to coincide with the period that smart devices were normalized in society, including chatbots); and (5) been written in any language and conducted in any country. Quantitative and qualitative peer-reviewed papers were included. For this study, chatbots were defined as programs that contained a conversational agent that could engage in "small talk"; smart conversational agents, such as Apple Siri; and those involving a computer-generated virtual agent.

Search Strategy

Initially, a limited search of Google and MEDLINE was completed by the authors to evaluate the scope of existing research in the literature. The search strategy was developed in conjunction with the academic liaison librarian. An advanced search was conducted in March 2022 using MEDLINE, including Medical Subject Headings (MeSH) and keyword searches, in 3 core concept areas: chatbots, nutrition intervention, and physical activity intervention. An extensive list of synonyms for all terms was included to capture the maximum number of studies (Multimedia Appendix 1). Once key concepts and terms were determined, the search strategy was adapted to other database searches. The search was implemented using 6 electronic databases (MEDLINE, Embase, Joanna Briggs Institute [JBI], the Cumulative Index to Nursing and Allied Health [CINAHL], the Association for Computing Machinery [ACM] library, and the IT database Institute of Electrical and Electronics Engineers [IEEE]). We also conducted gray literature searches to identify any papers that may have been missed through the search.

Screening and Study Selection

All search results were stored in an Endnote library (Endnote X9.3.3, Clarivate), and duplicates were removed. Next, the Endnote library was uploaded to Covidence (Veritas Health Innovation Ltd), and additional duplicates were removed. The PRISMA-ScR model was used to screen and select studies. Title and abstract screening and full-text screening were conducted based on the inclusion criteria. Two reviewers (authors RH and SW) performed the source selection independently. Any disagreements were discussed between the 2 reviewers, and if the conflicts were not resolved, further discussion with a third reviewer (author RR) was undertaken.

Data Exaction and Presentation of Results

Two authors conducted data extraction independently (authors RH and AT), with consensus provided by a third reviewer (RR). The data were extracted using predeveloped data extraction tables. The extracted results were descriptively mapped in tables and a narrative summary.

Consultation Exercise

One author (RR) presented an overview of the results of the scoping review to an established youth advisory group, which includes 16 adolescents aged 13-18 years, residing in New South Wales, Australia (Health Advisory Panel for Youth at the University of Sydney [HAPYUS]). The youth advisory group was recruited via social media advertising and went through a competitive selection process. They serve a 12-month term on the panel, providing their input to several adolescent research projects [30,31]. The results were presented to the youth advisory group to gain valuable insights into issues relating to the results that the scoping review alone would not have alerted the research team to. After presentation of the scoping review, 2 members of the youth advisory group volunteered to lead a statement on behalf of the group, included in the Results section, relating to considerations for researchers or developers working in this area. This statement was written by HAPYUS in their own words.

Ethical Considerations

Ethics approval was not required. The adolescents who took part in the consultation were considered members of our research team.

Results

Study Selection

The search identified 5558 papers that were imported for screening, and 85 (1.5%) duplicates were removed. After title and abstract screening, 5383 (98.4%) of 5473 papers were excluded. The remaining 90 (1.6%) full-text papers were screened, and 86 (95.6%) papers were excluded. Overall, a total of 4 (4.4%) relevant papers were identified through database searching. One additional paper was discovered through gray literature searching (Figure 1). The 5 studies were conducted in different countries: Korea, India, Finland, Switzerland, and Belgium. Among the 5 studies, 3 (60.0%) interventional studies were identified, 2 (66.7%) of which were randomized controlled trials (RCTs) and 1 (33.3%) was a pre-post study. In addition,

1 (20.0%) of the 5 studies was an exploratory analysis as a subset of an RCT and 1 (20.0%) was a mixed methods pilot study. A narrative summary of the results of the included studies and characteristics of chatbots is presented in Tables 1 and 2, respectively.

Figure 1. PRISMA-ScR flow diagram. PRISMA-ScR: Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping reviews.

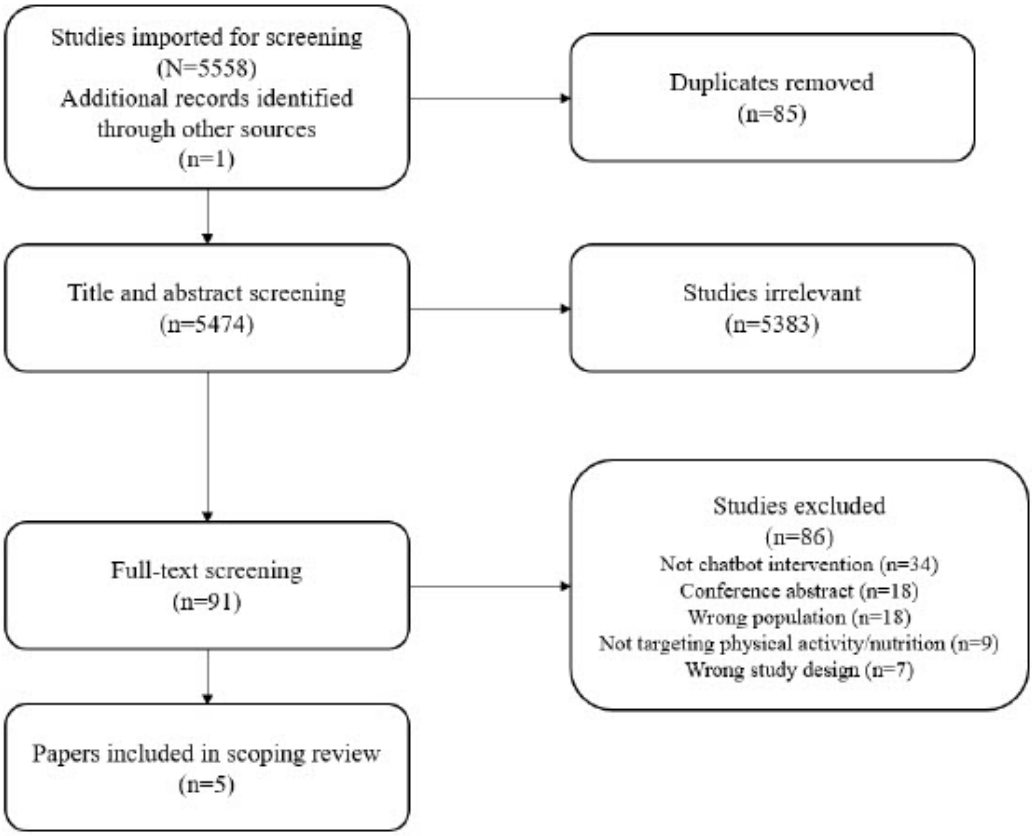


Table 1. Key characteristics of included studies.

First author, year, country	Study design	Recruitment	Participants, N	Sex	Age range (years)	Aim	Use of codesign in chatbot development	Dropout
Lee, 2017, Korea [32]	Pre-post intervention	Students from 2 same-sex high schools in Seoul, Korea	33	Female: n=24, 72.7%; Male: n=9, 27.3%	16-18	To test the feasibility of a mobile app Diet-A and examine whether Diet-A could be used to monitor dietary intake among adolescents	N/A[a]	N/A
Padman, 2017, India [33]	Exploratory analysis	Students from 3 middle schools in urban India recruited for an RCT and deidentified participants from the RCT recruited in the explanatory analysis	14	Female: n=7, 50.0%; Male: n=7, 50.0%	10-11	To analyze game telemetry to understand user interactions from playing Fooya! and provide new insight for designing interventions via games to improve pediatric overweight and obesity rates	N/A	N/A
Pyky, 2017, Finland [34]	RCT[b]	Males who for conscripted for military service in Finland	496	Male: n=100, 100.0%	Mean 17.8	To assess whether a tailored mobile physical activity intervention can improve life satisfaction and self-rated health among young adolescent men	16-20-year-old males involved in the design, development, and testing of the mobile service	Lost to follow-up: n=151, 30.4%; Controls: n=167, 33.7%; Intervention: n=135, 27.2%
Stasinaki, 2021, Switzerland [35]	RCT	Children's Hospital of Eastern Switzerl (specialized childhood obesity management center)	31	Female: n=13, 41.9%; Male: n=18, 58.1%	10-18	To assess whether PathMate2 can improve the BMI (kg/m^2), physical capacities, and stress parameters in adolescents with obesity, under the supervision of pediatric obesity experts	N/A	Lost to follow-up: 0.1%
Maenhout, 2021, Belgium [36]	Mixed methods pilot study	Flemish secondary schools	Phase 1: 36; Phase 2: 6; Phase 3: 81	Phase 1: Female: n=29, 80.6%; Male: n=7, 19.4%; Phase 2: Female: n=6, 100.0%; Phase 3: N/A	12-15	To assess the feasibility and engagement of a chatbot protype among adolescents to promote healthy behaviors	Phase 1: focus groups to inform the development of the chatbot prototype, including content and design; Phase 2: pretest of the protype	Phase 3: quit after receiving a wrong answer from the chatbot: n=61, 66.7%

[a]N/A: not applicable.

[b]RCT: randomized controlled trial.

Table 2. Summary of chatbots.

First author, year, country	Chatbot name	Intervention delivery	Conversational agent	Gamification	Personalized feedback	Monitored behavior change
Lee, 2017, Korea [32]	Diet-A	Mobile app	Yes	No	Yes	Yes
Padman, 2017, India [33]	Fooya!	Mobile app	No	Yes	No	No
Pyky, 2017, Finland [34]	MOPOrtal	Mobile service	Yes	Yes	Yes	Yes
Stasinaki, 2021, Switzerland [35]	PathMate2	Mobile app	Yes	Yes	Yes	Yes
Maenhout, 2021, Belgium [36]	Self-regulation app	Mobile app	Yes	No	Yes	Yes

Overview of Included Studies

Studies recruited adolescents aged 10-19 years. Of the 5 studies, 4 (80.0%) had small sample sizes with varying distributions of male and female participants. In addition, 1 (20.0%) study had an even distribution of males and females [33], 2 (40.0%) studies had more than 70.0% female participants [32,36], and 2 (40.0%) studies had predominantly (58.0% and 100.0%, respectively) male participants [34,35]. An overview of the included studies is provided in Table 1, including key characteristics of the included studies (eg, authors, year of publication, country, aim, study type, participant characteristics). In the included studies, 1 (20.0%) study included adolescents with overweight or obesity recruited from a hospital setting [35]. The other 4 (80.0%) studies included participants who were otherwise healthy [32-34,36]. In addition, 3 (60.0%) studies were conducted in school settings, of which 2 (66.7%) were conducted in high schools and 1 (33.3%) in middle schools [32,33,36]. Furthermore, 1 (20.0%) study recruited only males eligible for military conscription [34].

Summary of Chatbots

The 5 chatbots were supported by mobile apps (n=4, 80.0%) or web applications delivered via mobile devices (n=1, 20.0%). The 5 chatbots were different in their delivery. The chatbots used a combination of 4 features, namely a conversational agent (n=4, 80.0%), gamification (n=3, 06.0%), personalized feedback (n=4, 80.0%), and monitoring of behavior change (n=4, 80.0%). An overall summary of the chatbots is provided in Table 2, including the characteristics of the intervention in more detail (chatbot details, intervention details, outcomes and key findings that relate to the scoping review question). In the 5 studies, chatbots were used in different ways to improve adolescents' nutrition and physical activity behaviors. Nutrition was the focus of 2 (40.0%) studies, in which chatbots targeted nutrition intake and food choice [32,33]. Physical activity was the focus of 2 (40.0%) studies, in which chatbots targeted physical activity, physical capacity, and the BMI [34,35]. Finally, 1 (20.0%) study had a chatbot that targeted both nutrition and physical activity behaviors [36]. Each intervention targeted nutrition and physical activity differently. Diet-A used a mobile app where the participants recorded their dietary intake and provided real-time, personalized feedback on their diet [32]. Fooya! was an interactive mobile game and AI robot that aimed to influence healthy food choices [33]. The 2 chatbots targeting physical activity had unique features in their delivery to help participants achieve their goals. PathMate2 was a virtual health coach [35], and MOPOrtal was a web-based interface with a combined mixed-reality game [34]. The self-regulation app that targeted physical activity and nutrition behaviors allowed participants to ask the chatbot questions about physical activity, sedentary behavior, breakfast intake, and mental health [36].

Summary of Feasibility and Acceptability of Chatbots

Overall, there were mixed reports of the feasibility and acceptability of chatbots across all 5 studies. Of the participants who used Diet-A, 61.9% (13/21) said they were satisfied with it to monitor their dietary intake, 65.0% (13/20) said it was helpful, and 57.1% (12/21) agreed that they were able to learn about their dietary intake. However, 71.4% (15/21) of the participants reported that it was burdensome and 85.7% (18/21) reported that they sometimes forgot to record their diet [32]. In the Fooya! mobile app, participants gained knowledge and awareness of healthy food, but engagement decreased throughout the game [33]. In the MOPOrtal intervention, there were low overall intervention effects, except in participants who reported poorer health at baseline. No other data on feasibility or acceptability were reported [34]. PathMate2 was still being used by just over half of the participants (51.0%) at 6 months. The average app usage rate was 71.5%, and the average adherence rate was 57.2% during the intervention [35]. Finally, for the self-regulation app, 74.1% (60/81) of participants used the chatbot during the pilot; however, two-thirds of these participants quit and did not ask any further questions if the chatbot gave a wrong answer [36].

Summary of Health Outcomes

Of the 5 studies, 3 (60.0%) studies recorded and analyzed participants' health-related characteristics at baseline and after the intervention, with the length of the interventions ranging from 3 to 6 months [32,34,35], and 1 (20.0%) study had an additional 6-month maintenance phase to measure sustained changes [35]. The Diet-A intervention used the CAN-Pro 4.0 program to assess nutrient intake through 24-hour recalls pre- and postintervention. This study found that participants had a significant reduction in sodium and calcium intake and an increase in fruit and vegetable consumption. However, there was no improvement in overall diet among the participants following the intervention [32]. MOPOrtal measured daily minutes of physical activity through a physical activity monitor and collected height and weight to calculate the BMI. It demonstrated a limited increase in physical activity and increased mean weight in both intervention and control groups. Only those men with low life satisfaction and poor self-rated health at baseline were associated with improved satisfaction postintervention [34]. Finally, PathMate2 measured the BMI-SDS (where SDS refers to the standard deviation score) and other anthropometric measures and found that participants can improve physical capacity, increase muscle mass, and reduce body fat percentage following use of the intervention, but there was no sustained significant change in the BMI-SDS [35]. The other 2 (40.0%) studies did not measure any health-related characteristics. A full summary of outcomes is provided in Multimedia Appendix 2.

Summary of Chatbot Development

Of the 5 chatbots, 4 (80.0%) used text-based mobile apps yet were developed in different ways, including based on health databases, transtheoretical models, scientific evidence, and the person-based approach (PBA) [32,34-36]. The mobile app Diet-A, developed by Lee et al [32], is a self-monitoring app to help participants record their diet and offers real-time feedback and disease prevention information based on dietary reference intakes for Koreans. The feedback and disease prevention information were built under 3 health and food-related databases, and nutrient content information was provided by external stakeholders [32]. MOPOrtal can deliver tailored health information and feedback messages in line with Finnish national physical activity recommendations for

13-18-year-olds. The messages delivered were based on the transtheoretical model of behavior change. The given message was different at each intervention stage to match the process of change theorized and provide the most appropriate information to the participants. The health information was based on the reviewed scientific evidence [34]. The PathMate2 mobile app included a conversational agent as a virtual coach and was developed with MobileCoach open source software. This agent can chat with participants and encourage them to achieve the challenge of staying healthy through physical activity according to Swiss physical activity guidelines. PathMate2 aimed to support behavior change using goal setting, self-monitoring, stimulus control, and behavioral contracting to support a healthy lifestyle [35]. Finally, Maenhout et al [36] used PBA to ensure the needs and perspectives of the end user were embedded in the guiding principles of the chatbot, and therefore, health information delivered was not based on any guidelines but rather was based on content adolescents wished to receive. Dialogflow software was used to develop the intervention, and behavior change was promoted using the Health Action Process Approach model [36]. Moreover, there was 1 (20.0%) study that examined a virtual reality–based mobile game that was supported by AI (food robot), which was different from the other 4 (80.0%) chatbots and used personalized behavior reinforcement to increase awareness and self-efficacy [33]. Only 2 (40.0%) of 5 studies used any codesign with the end user, and no studies involved parents or caregivers in the intervention development.

Youth Consultation

The youth consultation led to the statement seen in Textbox 1. In brief, adolescents had concerns around (1) information the chatbots delivered being misleading or harmful and (2) ethical concerns around the privacy of data collected and misunderstanding of individual circumstances that may provide inaccurate health advice.

Textbox 1. Youth statement in their own words.

> Chatbots have great potential in the field of health promotion, particularly in areas that encompass physical activity and nutrition. However, there are many factors that must be considered before they are implemented in such a field. The extensive growth and use of social media and the sharing of public information [have] seen society enter a world of fake, or rather, misleading information. This has created an environment where it is hard to navigate what is the truth and what is harmful. Therefore, any information that the chatbots release must be highly regulated and fact-checked before [being] released. So many misleading and often harmful nutritional messages are put out to audiences that [result] in body dysmorphia, decreases in self-esteem, and eating disorders. The information used must be phrased in a manner that is not triggering nor encouraging such poor habits. To increase their acceptance in the wider population, the chatbot should be associated with a brand or source that already has a "trusted" label. This would make audiences more likely to engage with it.
>
> The ethical concerns of chatbots for uses in health promotion can be divided into 2 main categories: the potential for chatbots to exploit young people for commercial gain and the potential for chatbots to cause harm to young people through the provision of inaccurate health advice. There are several ways in which chatbots could exploit young people for commercial gain. Chatbots could be used to sell young people's personal data to third parties or to generate targeted advertising based on young peoples' health conditions. Chatbots could also be used to upsell young people on expensive treatments, exercise programsl, or supplements. To minimize the risk of chatbots exploiting young people for commercial gain, it is important to ensure that chatbots are transparent about how they will use any personal data that they collect. Young people should also be given the option to opt out of any data collection or advertising. There is also a risk that chatbots could cause harm to young people through the provision of inaccurate health advice. This could happen if chatbots are not based on credible health sources or if they are not able to properly understand young people's individual circumstances. To minimize the risk of chatbots causing harm to young people, it is important to ensure that chatbots are only used as a supplement to, and not a replacement for, health advice from a qualified health care professional.

Discussion

Principal Findings

This systematic scoping review evaluating chatbots in promoting nutrition and physical activity behaviors in adolescent populations is an emerging and underresearched field. The 5 published studies found insufficient evidence for the acceptability and feasibility of chatbots. Only 2 of the 5 included studies found adolescents were satisfied with the chatbot used in the intervention [32,33]. The chatbots demonstrated modest efficacy in improving adolescents' nutrition, physical activity behaviors, and knowledge. The chatbots were used within mobile apps or mobile services with differing design features, including conversational agents, gamification, personalized feedback, and monitoring of behavior change. Adolescents from the youth advisory group presented unique insights into the use of chatbots in nutrition and physical activity interventions, including ethical concerns and the use of false or misleading information, which was not otherwise identified in the published literature. Taking these findings together, this review found that there is limited evidence for the feasibility and acceptability of chatbots in promoting nutrition and physical activity behaviors. Therefore, together with our youth advisory group, we propose suggestions for improved chatbot development and research study design.

Comparison With Existing Literature

To the best of our knowledge, this is the first systematic scoping review of chatbots in promoting nutrition and physical activity behaviors in adolescent populations. Chatbots have been broadly used in chronic disease prevention and management. A systematic review conducted by Laranjo et al [37] demonstrated that conversational agents are most commonly used in mental health management, resulting in reduced depression symptoms, improved narrative skills scores in autism, and suicide prevention [37]. This review also highlighted conversational agents (1) supporting patients with type 2 diabetes for physical activity and diet behavior change and self-management practice and (2) supporting clinicians and hypertension patients in telemonitoring and data collection. In this review, 12 of the 14 studies reported user experience. Dissimilar to our findings, most reported high overall satisfaction. Of the 2 studies that included adolescent participants, the chatbot designed for self-management of a specific condition (asthma) [38] had a

higher overall satisfaction compared to the chatbot designed for education (sexual health and substance abuse) [39]. In our review, participants reported greater satisfaction with chatbots for self-monitoring of food consumption and dietary intake. However, most participants reported that chatbots were often not easy to use and sometimes forgot to record their dietary intake [32]. Consequently, participants tended to underreport their dietary intake using the app in comparison to other validated dietary recall methods. This may explain why studies in our review, which were focused on prevention and risk factor modification, not chronic disease self-management, had lower overall satisfaction. This also demonstrates the need to focus on design features.

There are other studies focusing on the feasibility of chatbots used in adolescents but not limited to nutrition and physical activity behavior change. A chatbot called Tess (X2 AI) using AI was found to be an engaging and feasible approach to support weight management and counseling in adolescents and children [40]. Participants reported Tess to be useful 96.0% of the time. The high level of satisfaction compared to the studies included in our review may be explained by the different length of conversations participants can have with Tess. Tess can offer large amounts of message exchanges, which demonstrates high engagement, attraction, and acceptability of AI chatbots [40]. It should be noted that Tess is a commercially available service with a customizable platform where the content can be tailored for specific populations or interventions. This is unlike the chatbots evaluated in this review, which were developed by the research teams for the purpose of 1 intervention. Consequently, integrating language techniques may be useful to incorporate into the chatbot database to enhance engagement with adolescents and stimulate longer message conversations, covering topics outside of the intervention itself.

NLP may be a good choice for chatbot database design for adolescents if databases can be developed to offer small talk and noninterventional questions, in addition to the intervention. In Maenhout et al's [36] study, adolescents found it frustrating if the chatbot misunderstood their question. A conservational agent that uses NLP may make them feel like they are communicating with another human, which in turn may enhance engagement and the user experience [36]. In a similar study, a chatbot using NLP that was focused on improving physical activity in adults found the chatbot increased participants' step count and self-reported physical activity. Most participants scored the chatbot as OK (78.8%), and one-third of the participants were interested in continuing using the chatbot following the study [41]. For NLP to be successful, it is vital to engage adolescents throughout the database design process to develop the database with youth-oriented language and enhance the feeling of communicating with another human. A scoping review by Kramer et al [42] found that conversational agents for coaching people in a healthy lifestyle were often designed for the end user rather than with the end user. In this review, only 2 of the 5 chatbots incorporated any kind of codesign with adolescents in the development of the chatbot intervention, which may explain the low satisfaction with the chatbots as they were not designed with the end user, and therefore do not meet the adolescents' needs.

The youth consultation uncovered insights into the use of chatbots for nutrition and physical activity interventions that were not identified in the published literature. One of the suggestions raised by adolescents was to have the chatbot associated with a brand. In a previous study, adolescents identified that the most helpful lifestyle health information online comes from a credible and reliable source [43]. Adolescents are highly brand conscious [44], and therefore, having the chatbot associated with a brand may increase their trust in the information that is being presented to them. Another insight raised by adolescents was around the provision of inaccurate health advice that may cause harm. To counter this, appropriate monitoring of chatbot conversation logs is vital in future studies to ensure chatbots do not deviate and provide incorrect information to adolescents. Conversation logs must also be monitored to ensure any self-disclosure from the adolescent to the chatbot is communicated and actioned accordingly. In the studies included in this review, there was no potential for chatbots to provide incorrect information as none of the conversational agents used AI to provide responses. Only 1 of the studies in this review applied monitoring of conversation logs, yet it was to assess the feasibility and not for safety. For chatbots to be both safe and effective in the future, researchers and developers must work together to obtain information about adolescents and their individual situation and then tailor accurate health information that is best suited to their needs. Furthermore, safeguards need to be in place to ensure the safety of adolescents while using chatbots for health promotion interventions [45], especially if future chatbots are developed using AI. Rigorous beta-testing of the intervention should occur before being implemented to ensure that interventions are relevant, appealing, functional, stable, and useful [46]. In addition, exposure time to the chatbots must also be considered in future interventions to ensure that adolescents do not increase their screen time beyond the recommended guidelines.

Limitations

This scoping review demonstrates the limited published literature on chatbots used in the adolescent population for nutrition and physical activity behavior promotion. It must be noted that there are some limitations to this research. First, not all studies provided data on the feasibility and acceptability of the chatbots, which is crucial to understanding barriers and enablers to implementing such an intervention on a wider scale. Second, none of the studies included in this review that included a conversational agent used AI. Chatbots based on AI are trained to respond to queries based on texts to which they are exposed; therefore, the training of AI chatbots could not be assessed within the scope of this review. Next, we only included peer-reviewed published studies. There is the potential of other studies that would otherwise fit the criteria of this review. Finally, youth consultation is a strength of our review; however, it was conducted in a group of Australian adolescents, so the results may not be generalizable to other populations.

Conclusion

Limited research is available on the use of chatbots in adolescent nutrition and physical activity interventions, finding insufficient

evidence for the acceptability and feasibility of chatbots in the adolescent population and only minor improvements in health-related outcomes due to the interventions. Similarly, adolescent consultation identified important issues relating to the design features that were not mentioned in the published literature. Researchers and developers should consider codesigning chatbots with adolescents to ensure that they are feasible and acceptable to an adolescent population.

Acknowledgments

A special acknowledgment to Fulin Yan and Alexi Cross for leading the youth consultation and the entire Health Advisory Panel for Youth at the University of Sydney 2021/22 (HAPYUS 2021/22), without whom this research would not be possible (Radhika Valanju, Meera Barani, Dominik Mautner, Imeelya Al Hadaya, Melani Gunawardana, Ava Lambie, Emily McMahon, Arnav Narula, Bowen Ren, Dominique R, Aviral Sharda, Alexander Sinnett, and Azman Tanvir).

Authors' Contributions

Conceptualization was handled by RH, SRP, and RR; methodology by RH, SRP, and RR; investigation by RH, SW, and AT; writing—original draft preparation by RH and AT; writing—review and editing by RH, AT, SW, SRP, and RR; and supervision by SRP and RR. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Search strategy.
[DOCX File , 16 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Characteristic of chatbots and interventions.
[DOCX File , 20 KB-Multimedia Appendix 2]

References

1. Adolescent health. World Health Organization. URL: https://www.who.int/health-topics/adolescent-health#tab=tab_1 [accessed 2022-09-28]
2. Childhood obesity: a growing pandemic. Lancet Diabetes Endocrinol 2022 Jan;10(1):1. [doi: 10.1016/s2213-8587(21)00314-4]
3. Guideline: implementing effective actions for improving adolescent nutrition. World Health Organization. 2018. URL: https://www.who.int/publications/i/item/9789241513708 [accessed 2022-09-28]
4. Obesity and overweight. World Health Organization. 2021. URL: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight [accessed 2022-09-28]
5. Beal T, Morris SS, Tumilowicz A. Global patterns of adolescent fruit, vegetable, carbonated soft drink, and fast-food consumption: a meta-analysis of global school-based student health surveys. Food Nutr Bull 2019 Dec;40(4):444-459 [FREE Full text] [doi: 10.1177/0379572119848287] [Medline: 31617415]
6. Norris SA, Frongillo EA, Black MM, Dong Y, Fall C, Lampl M, et al. Nutrition in adolescent growth and development. Lancet 2022 Jan;399(10320):172-184. [doi: 10.1016/s0140-6736(21)01590-7]
7. Rose T, Barker M, Maria Jacob C, Morrison L, Lawrence W, Strömmer S, et al. A systematic review of digital interventions for improving the diet and physical activity behaviors of adolescents. J Adolesc Health 2017 Dec;61(6):669-677 [FREE Full text] [doi: 10.1016/j.jadohealth.2017.05.024] [Medline: 28822682]
8. Côté M, Lamarche B. Artificial intelligence in nutrition research: perspectives on current and future applications. Appl Physiol Nutr Metab 2021 Sep 15:1-8. [doi: 10.1139/apnm-2021-0448] [Medline: 34525321]
9. Nemet D. Childhood obesity, physical activity, and exercise. Pediatr Exerc Sci 2017 Feb;29(1):60-62 [FREE Full text] [doi: 10.1123/pes.2017-0004] [Medline: 28271810]
10. Lee AM, Chavez S, Bian J, Thompson LA, Gurka MJ, Williamson VG, et al. Efficacy and effectiveness of mobile health technologies for facilitating physical activity in adolescents: scoping review. JMIR Mhealth Uhealth 2019 Feb 12;7(2):e11847 [FREE Full text] [doi: 10.2196/11847] [Medline: 30747716]
11. Sailer M, Hense J, Mayr S, Mandl H. How gamification motivates: an experimental study of the effects of specific game design elements on psychological need satisfaction. Comput Hum Behav 2017 Apr;69:371-380 [FREE Full text] [doi: 10.1016/j.chb.2016.12.033]
12. Mazeas A, Duclos M, Pereira B, Chalabaev A. Evaluating the effectiveness of gamification on physical activity: systematic review and meta-analysis of randomized controlled trials. J Med Internet Res 2022 Jan 04;24(1):e26779 [FREE Full text] [doi: 10.2196/26779] [Medline: 34982715]

13. Suleiman-Martos N, García-Lara RA, Martos-Cabrera MB, Albendín-García L, Romero-Béjar JL, Cañadas-De la Fuente GA, et al. Gamification for the improvement of diet, nutritional habits, and body composition in children and adolescents: a systematic review and meta-analysis. Nutrients 2021 Jul 20;13(7):2478 [FREE Full text] [doi: 10.3390/nu13072478] [Medline: 34371989]
14. Hargreaves D, Mates E, Menon P, Alderman H, Devakumar D, Fawzi W, et al. Strategies and interventions for healthy adolescent growth, nutrition, and development. Lancet 2022 Jan;399(10320):198-210. [doi: 10.1016/s0140-6736(21)01593-2]
15. Schoeppe S, Alley S, Rebar AL, Hayman M, Bray NA, Van Lippevelde W, et al. Apps to improve diet, physical activity and sedentary behaviour in children and adolescents: a review of quality, features and behaviour change techniques. Int J Behav Nutr Phys Act 2017 Jun 24;14(1):83 [FREE Full text] [doi: 10.1186/s12966-017-0538-3] [Medline: 28646889]
16. Smith JJ, Morgan PJ, Plotnikoff RC, Dally KA, Salmon J, Okely AD, et al. Smart-phone obesity prevention trial for adolescent boys in low-income communities: the ATLAS RCT. Pediatrics 2014 Sep;134(3):e723-e731 [FREE Full text] [doi: 10.1542/peds.2014-1012] [Medline: 25157000]
17. Partridge SR, Redfern J. Strategies to engage adolescents in digital health interventions for obesity prevention and management. Healthcare (Basel) 2018 Jun 21;6(3):70 [FREE Full text] [doi: 10.3390/healthcare6030070] [Medline: 29933550]
18. Kouvari M, Karipidou M, Tsiampalis T, Mamalaki E, Poulimeneas D, Bathrellou E, et al. Digital health interventions for weight management in children and adolescents: systematic review and meta-analysis. J Med Internet Res 2022 Feb 14;24(2):e30675 [FREE Full text] [doi: 10.2196/30675] [Medline: 35156934]
19. Davenport T, Kalakota R. The potential for artificial intelligence in healthcare. Future Healthc J 2019 Jun;6(2):94-98 [FREE Full text] [doi: 10.7861/futurehosp.6-2-94] [Medline: 31363513]
20. Bickmore TW, Trinh H, Olafsson S, O'Leary TK, Asadi R, Rickles NM, et al. Patient and consumer safety risks when using conversational assistants for medical information: an observational study of Siri, Alexa, and Google Assistant. J Med Internet Res 2018 Sep 04;20(9):e11510 [FREE Full text] [doi: 10.2196/11510] [Medline: 30181110]
21. Alagha EC, Helbing RR. Evaluating the quality of voice assistants' responses to consumer health questions about vaccines: an exploratory comparison of Alexa, Google Assistant and Siri. BMJ Health Care Inform 2019 Nov 24;26(1):e100075 [FREE Full text] [doi: 10.1136/bmjhci-2019-100075] [Medline: 31767629]
22. Lee J, Yang H, Shin D, Kim H. Chatbots. ELT Journal 2020;74(3):338-344 [FREE Full text] [doi: 10.1093/elt/ccaa035]
23. Oh YJ, Zhang J, Fang M, Fukuoka Y. A systematic review of artificial intelligence chatbots for promoting physical activity, healthy diet, and weight loss. Int J Behav Nutr Phys Act 2021 Dec 11;18(1):160 [FREE Full text] [doi: 10.1186/s12966-021-01224-6] [Medline: 34895247]
24. Chew HSJ. The use of artificial intelligence-based conversational agents (chatbots) for weight loss: scoping review and practical recommendations. JMIR Med Inform 2022 Apr 13;10(4):e32578 [FREE Full text] [doi: 10.2196/32578] [Medline: 35416791]
25. Zhang J, Oh YJ, Lange P, Yu Z, Fukuoka Y. Artificial intelligence chatbot behavior change model for designing artificial intelligence chatbots to promote physical activity and a healthy diet: viewpoint. J Med Internet Res 2020 Sep 30;22(9):e22845 [FREE Full text] [doi: 10.2196/22845] [Medline: 32996892]
26. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Med Res Methodol 2018 Nov 19;18(1):143 [FREE Full text] [doi: 10.1186/s12874-018-0611-x] [Medline: 30453902]
27. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol 2005 Feb;8(1):19-32. [doi: 10.1080/1364557032000119616]
28. Peters MG, McInerney P, Munn Z, Tricco A, Khalil H. Scoping reviews. In: Aromataris E, Munn Z, editors. The BI Manual for Evidence Synthesis. Adelaide, South Australia: JBI; 2020.
29. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med 2018 Oct 02;169(7):467-473 [FREE Full text] [doi: 10.7326/M18-0850] [Medline: 30178033]
30. Raeside R, Spielman K, Maguire S, Mihrshahi S, Steinbeck K, Kang M, Health4Me Team. A healthy lifestyle text message intervention for adolescents: protocol for the Health4Me randomized controlled trial. BMC Public Health 2022 Sep 23;22(1):1805 [FREE Full text] [doi: 10.1186/s12889-022-14183-9] [Medline: 36138375]
31. Valanju R, Barani M, Mautner D, Al Hadaya I, Cross A, Gunawardana M, et al. Youth perspective on chronic disease prevention. Lancet Child Adolesc Health 2022 Jul;6(7):456-458. [doi: 10.1016/s2352-4642(22)00131-6]
32. Lee J, Song S, Ahn JS, Kim Y, Lee JE. Use of a mobile application for self-monitoring dietary intake: feasibility test and an intervention study. Nutrients 2017 Jul 13;9(7):748 [FREE Full text] [doi: 10.3390/nu9070748] [Medline: 28703758]
33. Padman R, Gupta D, Sri Prakash B, Krishnan C, Panchatcharam K. An exploratory analysis of game telemetry from a pediatric mHealth intervention. Stud Health Technol Inform 2017;245:183-187. [Medline: 29295078]
34. Pyky R, Koivumaa-Honkanen H, Leinonen A, Ahola R, Hirvonen N, Enwald H, et al. Effect of tailored, gamified, mobile physical activity intervention on life satisfaction and self-rated health in young adolescent men: A population-based, randomized controlled trial (MOPO study). Comput Hum Behav 2017 Jul;72:13-22. [doi: 10.1016/j.chb.2017.02.032]

35. Stasinaki A, Büchter D, Shih CI, Heldt K, Güsewell S, Brogle B, et al. Effects of a novel mobile health intervention compared to a multi-component behaviour changing program on body mass index, physical capacities and stress parameters in adolescents with obesity: a randomized controlled trial. BMC Pediatr 2021 Jul 09;21(1):308 [FREE Full text] [doi: 10.1186/s12887-021-02781-2] [Medline: 34243738]
36. Maenhout L, Peuters C, Cardon G, Compernolle S, Crombez G, DeSmet A. Participatory development and pilot testing of an adolescent health promotion chatbot. Front Public Health 2021 Nov 11;9:724779 [FREE Full text] [doi: 10.3389/fpubh.2021.724779] [Medline: 34858919]
37. Laranjo L, Dunn AG, Tong HL, Kocaballi AB, Chen J, Bashir R, et al. Conversational agents in healthcare: a systematic review. J Am Med Inform Assoc 2018 Sep 01;25(9):1248-1258 [FREE Full text] [doi: 10.1093/jamia/ocy072] [Medline: 30010941]
38. Rhee H, Allen J, Mammen J, Swift M. Mobile phone-based asthma self-management aid for adolescents (mASMAA): a feasibility study. Patient Prefer Adherence 2014;8:63-72 [FREE Full text] [doi: 10.2147/PPA.S53504] [Medline: 24470755]
39. Crutzen R, Peters GY, Portugal SD, Fisser EM, Grolleman JJ. An artificially intelligent chat agent that answers adolescents' questions related to sex, drugs, and alcohol: an exploratory study. J Adolesc Health 2011 May;48(5):514-519. [doi: 10.1016/j.jadohealth.2010.09.002] [Medline: 21501812]
40. Stephens TN, Joerin A, Rauws M, Werk LN. Feasibility of pediatric obesity and prediabetes treatment support through Tess, the AI behavioral coaching chatbot. Transl Behav Med 2019 May 16;9(3):440-447. [doi: 10.1093/tbm/ibz043] [Medline: 31094445]
41. To QG, Green C, Vandelanotte C. Feasibility, usability, and effectiveness of a machine learning-based physical activity chatbot: quasi-experimental study. JMIR Mhealth Uhealth 2021 Nov 26;9(11):e28577 [FREE Full text] [doi: 10.2196/28577] [Medline: 34842552]
42. Kramer LL, Ter Stal S, Mulder BC, de Vet E, van Velsen L. Developing embodied conversational agents for coaching people in a healthy lifestyle: scoping review. J Med Internet Res 2020 Feb 06;22(2):e14058 [FREE Full text] [doi: 10.2196/14058] [Medline: 32022693]
43. Raeside R, Jia SS, Redfern J, Partridge SR. Navigating the online world of lifestyle health information: qualitative study with adolescents. JMIR Pediatr Parent 2022 Feb 11;5(1):e35165 [FREE Full text] [doi: 10.2196/35165] [Medline: 35147506]
44. Nelson M, McLeod L. Adolescent brand consciousness and product placements: awareness, liking and perceived effects on self and others. Int J Cons Stud 2005 Nov;29(6):515-528 [FREE Full text] [doi: 10.1111/j.1470-6431.2005.00429.x]
45. Thompson D, Baranowski T. Chatbots as extenders of pediatric obesity intervention: an invited commentary on "Feasibility of Pediatric Obesity & Pre-Diabetes Treatment Support through Tess, the AI Behavioral Coaching Chatbot". Transl Behav Med 2019 May 16;9(3):448-450. [doi: 10.1093/tbm/ibz065] [Medline: 31094432]
46. Youth-centred digital health interventions: a framework for planning, developing and implementing solutions with and for young people. World Health Organization. 2021 Jul 19. URL: https://www.who.int/publications/i/item/9789240011717 [accessed 2023-04-24]

Abbreviations

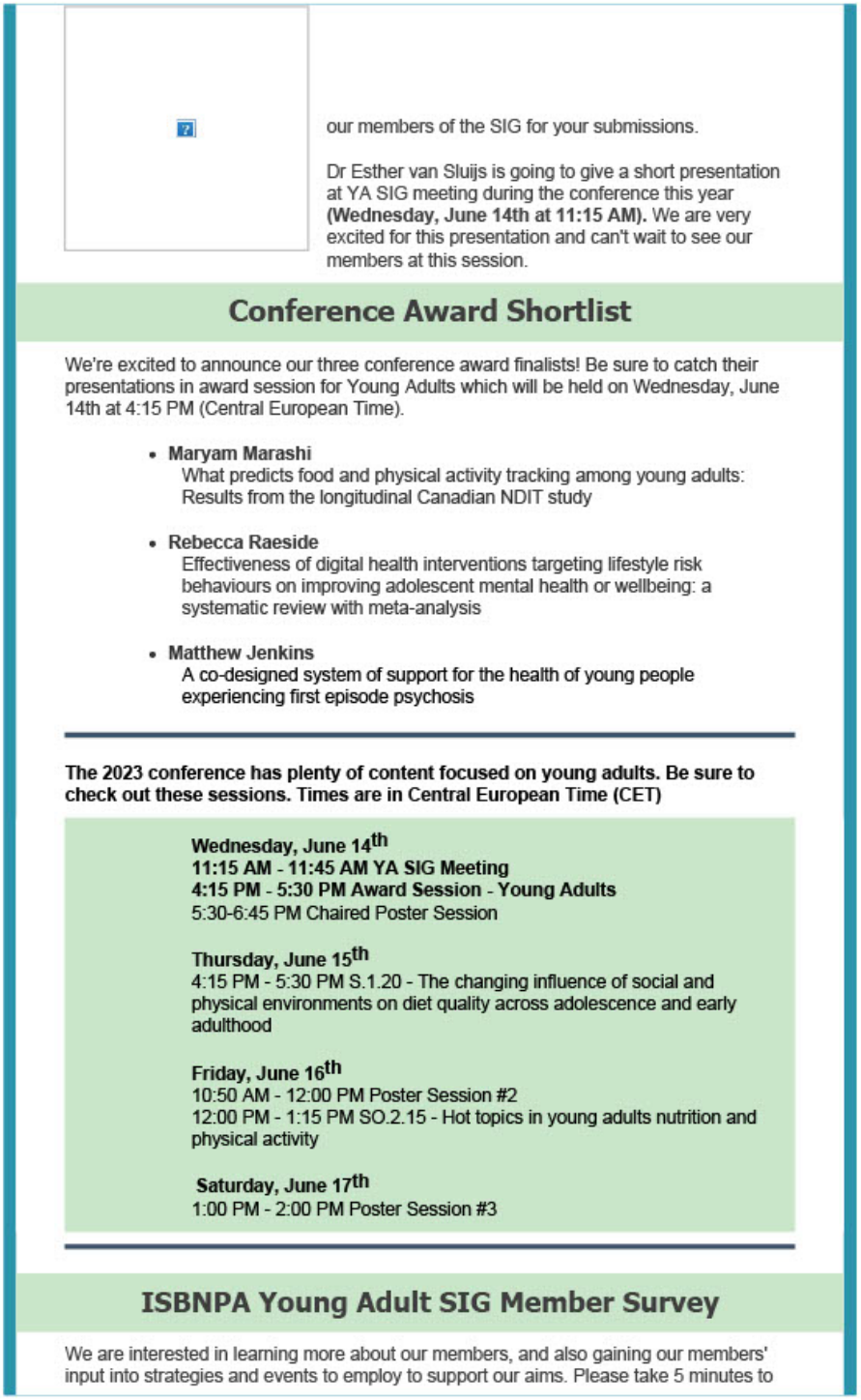
AI: artificial intelligence
HAPYUS: Health Advisory Panel for Youth at the University of Sydney
NLP: natural language processing
PBA: person-based approach
PRISMA-ScR: Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping reviews
RCT: randomized controlled trial
WHO: World Health Organization

Edited by A Kushniruk; submitted 04.10.22; peer-reviewed by M Vajravelu, T Baranowski; comments to author 26.02.23; revised version received 15.03.23; accepted 13.04.23; published 05.05.23

Please cite as:
Han R, Todd A, Wardak S, Partridge SR, Raeside R
Feasibility and Acceptability of Chatbots for Nutrition and Physical Activity Health Promotion Among Adolescents: Systematic Scoping Review With Adolescent Consultation
JMIR Hum Factors 2023;10:e43227
URL: https://humanfactors.jmir.org/2023/1/e43227
doi: 10.2196/43227
PMID: 37145858

Appendix G – Media Arising from Thesis

Conference Award Shortlist - International Society of Behavioural Nutrition and Physical Activity Young Adult Special Interest Group Newsletter



our members of the SIG for your submissions.

Dr Esther van Sluijs is going to give a short presentation at YA SIG meeting during the conference this year **(Wednesday, June 14th at 11:15 AM).** We are very excited for this presentation and can't wait to see our members at this session.

Conference Award Shortlist

We're excited to announce our three conference award finalists! Be sure to catch their presentations in award session for Young Adults which will be held on Wednesday, June 14th at 4:15 PM (Central European Time).

- **Maryam Marashi**
  What predicts food and physical activity tracking among young adults: Results from the longitudinal Canadian NDIT study
- **Rebecca Raeside**
  Effectiveness of digital health interventions targeting lifestyle risk behaviours on improving adolescent mental health or wellbeing: a systematic review with meta-analysis
- **Matthew Jenkins**
  A co-designed system of support for the health of young people experiencing first episode psychosis

The 2023 conference has plenty of content focused on young adults. Be sure to check out these sessions. Times are in Central European Time (CET)

Wednesday, June 14th
11:15 AM - 11:45 AM YA SIG Meeting
4:15 PM - 5:30 PM Award Session - Young Adults
5:30-6:45 PM Chaired Poster Session

Thursday, June 15th
4:15 PM - 5:30 PM S.1.20 - The changing influence of social and physical environments on diet quality across adolescence and early adulthood

Friday, June 16th
10:50 AM - 12:00 PM Poster Session #2
12:00 PM - 1:15 PM SO.2.15 - Hot topics in young adults nutrition and physical activity

Saturday, June 17th
1:00 PM - 2:00 PM Poster Session #3

ISBNPA Young Adult SIG Member Survey

We are interested in learning more about our members, and also gaining our members' input into strategies and events to employ to support our aims. Please take 5 minutes to

Five minutes with Rebecca Raeside, PhD - Digital Health and Informatics Network Newsletter

Five minutes with Rebecca Raeside, PhD

1). Please tell us a little about yourself

My name is Rebecca and I am a PhD Candidate and Research Associate in the Engagement and Co-design Research Hub in the School of Health Sciences, Faculty of Medicine and Health, University of Sydney. My background is in public health, and over the past 3 years have been working on multiple digital health research projects in the areas of cardiovascular disease, breast cancer, online food delivery with an overall focus on improving lifestyle risk factors to prevent chronic diseases.

2). What is your research on?

My current research focus is in primary prevention of chronic diseases in adolescents. My PhD focuses on the co-design, development and testing of a 6-month healthy lifestyle text message program to support physical and mental health in adolescents and strengthen engagement with primary care. We have set up a youth advisory group (named Health Advisory Panel for Youth at the University of Sydney, or HAPYUS for short!) who are 16 young people aged 13-18 from across NSW who we work side-by-side with to develop the text message intervention. By co-designing the intervention with the end user, we can ensure that the program addresses all the top issues which adolescents currently face in terms of their physical and mental health. By delivering the program via text messages, we can reach young people Australia wide using a technology which they use daily.

3). What are the real world consequences of your research?

The rise of chronic diseases is one of the biggest issues facing today's young people. Current approaches to obesity prevention are proving ineffective and there is an escalating mental health crisis for young people in Australia. Positively framed prevention programs which focus on good nutrition and physical activity can address both critical issues, while also addressing the stigma that is linked to traditional obesity or mental health focused programs. My research will provide high quality evidence on engagement with and effectiveness of a text message program available to all adolescents to improve physical and mental health outcomes and long-term risk of developing chronic diseases. By addressing multiple interlinked health risk factors in one program, this proposal aligns directly with the National Action Plan for Health of Young People to 'address chronic conditions and preventive health'.

4). What does digital health mean to you?

Digital health sits at the intersection of healthcare and technology sectors and I believe it has huge potential to break down existing barriers to delivering health information, healthcare and support to people and improve access. It is multidisciplinary and by using it we can develop cutting-edge solutions to problems which have existed in the

healthcare system for many years! It can also help to improve current processes in delivering healthcare.

5). Do you have any resources or links you would like to share?

In 2021, the WHO released a framework for planning, developing and implementing youth-centred digital health interventions: https://www.who.int/publications/i/item/9789240011717. I find this a great resource and for others doing research in digital health and young people this may be helpful.

Connect with Rebecca on Twitter @RebeccaRaeside

CSANZ Research Scholarship Winners: Rebecca Raeside and Thomas Meredith. On The Pulse – The official newsletter of the Cardiac Society of Australia and New Zealand

2022 CSANZ Research Scholarship Winners Rebecca Raeside and Thomas Meredith

Congratulations to Rebecca Raeside, PhD Candidate, Research Officer at the University of Sydney

Rebecca's Project : Health4Me Randomised Controlled Trial (RCT): primary prevention of cardiovascular disease among young people.

The Project Synopsis:
The current picture of young peoples' health in Australia is alarming with escalating health risks such as poor diet, physical inactivity, increased screen time and poor mental health becoming widely prevalent. These health risks can lead to chronic health problems such as heart disease in adulthood. Australia's 3.3 million teenagers have little support to manage these health risks and accessible, engaging programs that support a healthy lifestyle are urgently needed. My innovative Health4Me program will strive to solve this problem. We know that text message healthy lifestyle programs in adults have improved health outcomes and resulted in positive behaviour change. Over the next 3 years, I will lead a research project that will develop and test an engaging healthy lifestyle program for teenagers using text messages, a method through which they communicate every day. I will work with teenagers to co-create the Health4Me program using an established process. I will test how effective Health4Me is in a randomised clinical trial (330 teenagers) and evaluate if the program improves physical and mental health outcomes, whether it is acceptable and engaging and if the program can be embedded into the Australian healthcare system. If it helps, it can be scaled up to deliver to teenagers throughout Australia to improve health outcomes.

Congratulations to Dr Thomas Meredith,
Victor Chang Cardiac Research Institute, UNSW

Tom's Project : Improving therapeutic decision making in aortic valve stenosis

The Project Synopsis:
Aortic stenosis is the most common heart valve disease. It is characterised by a complex interplay between the aortic valve and the heart muscle (ventricular) function, making diagnosis and treatment timing challenging. Although replacement of the aortic valve has improved the prognosis of this condition, the current recommendations for the timing of replacement are associated with a highly advanced disease state and oftentimes sub-clinical heart muscle dysfunction, which is not only likely irreversible, but also portends a worse prognosis. It is possible that there may be a significant advantage to aortic valve intervention prior to the end-stage disease state which currently forms the basis for guideline recommendations. In the proposed doctoral research, we aim to better predict the response to therapy in aortic stenosis and identify factors associated with a favourable response to aortic valve intervention, such that we can help individualise treatment for patients and improve survival.