Understanding and preventing poor diet, alcohol use, tobacco smoking and vaping among adolescents from low socioeconomic and remoteness areas through eHealth interventions

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Abstract

Chronic diseases disproportionately affect disadvantaged populations, including individuals of low socioeconomic status (SES) and those living in geographically remote ('regional', 'rural', and 'remote') areas. These health inequities are systemic, unjust, and preventable. Adolescence represents a critical period for shaping future health behaviours and outcomes, offering a pivotal opportunity to mitigate the burden of chronic disease and reduce disparities. During this key developmental period, lifestyle risk behaviours such as poor diet, alcohol use, tobacco smoking, and vaping typically emerge. Evidence-based prevention strategies during adolescence are essential to prevent the entrenchment and progression of these lifestyle risk behaviours into adulthood, thereby addressing the widening health equity gap faced by disadvantaged populations.

This thesis aims to address critical gaps in the literature concerning lifestyle risk behaviours among adolescents from low SES and geographically remote contexts, with a primary focus on Australian adolescents. It also contributes to the global evidence base by offering strategies for the development of effective and equitable lifestyle behaviour interventions in both the Australian and international context.

Chapter 2 of this thesis examines the prevalence of poor diet, alcohol use, tobacco smoking, and vaping behaviours across a large and geographically diverse sample of 4,445 Australian adolescents aged 14-17 years. The findings reported a nuanced and complex picture of these behaviours, showing that there are no uniform patterns of these behaviours across SES and geographical locations. Lower SES adolescents reported less excessive discretionary food intake and alcohol consumption compared to their mid-to-high SES peers. In contrast, regional adolescents faired considerably worse across alcohol and tobacco outcomes compared to their peers in major cities. **Chapter 3** systematically synthesised the existing global evidence on electronic health (eHealth) interventions targeting poor dietary habits, alcohol use, tobacco smoking, and vaping among disadvantaged adolescents. The findings support eHealth interventions in improving dietary habits and reducing alcohol use among disadvantaged adolescents, but lacked evidence for addressing tobacco smoking, and vaping. **Chapter 4** applied latent growth curve modelling to evaluate the moderating effects of SES and geographical location, on the efficacy of a universal eHealth, school-based intervention, *Health4Life*, in targeting poor diet, alcohol use, tobacco smoking, behavioural intentions (diet-, alcohol-, and tobacco-related), psychological distress and knowledge over 24-months.

There was little evidence of a moderation effect on most outcomes, with the exception of diet-related outcomes by geographical location. Adolescents in regional areas in the intervention group reported poorer dietary habits than the control group, whereas adolescents in major cities in the intervention group reported greater intentions to swap sugar-sweetened-beverages for water than the control group. **Chapter 5** conducted a process evaluation of *Health4Life* among disadvantaged adolescents and their teachers to gain insights into the feasibility and acceptability of the intervention in disadvantaged schools. The findings revealed that content and technical challenges were key barriers to acceptability among disadvantaged adolescents, with participants identifying areas for refinement. Lastly, **Chapter 6**, evaluated the acceptability, and potential global scalability, of an effective eHealth school-based alcohol use prevention program, the *OurFutures Alcohol Module,* among disadvantaged adolescents in Bogotá, Colombia. The results support that with appropriate place-based end-user involvement in co-designing the adaptation, the *OurFutures Alcohol Module* could be an acceptable and engaging alcohol prevention program in Bogotá.

This thesis outlines actionable recommendations for policy, public health, and research to support the development of more effective and equitable lifestyle behaviour interventions for disadvantaged youth. These insights have global implications for the design, implementation and scalability of such interventions. Applying these insights has the potential to improve chronic disease outcomes for disadvantaged adolescents on a global scale.

Statement of Originality

This thesis is submitted in fulfilment of the requirements for the degree of Doctor of Philosophy (Medicine) at The University of Sydney.

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 assistance received in preparing this thesis and all sources used have been acknowledged.

Lyra Egan
12 December 2024

Thesis funding

This research reported in this thesis was supported by the award of two University of Sydney scholarships to the PhD Candidate Lyra Egan:

- Health4Life Initiative Postgraduate Research Scholarship (funded by the Paul Ramsay Foundation)
- Postgraduate Research Supplementary Scholarship in eHealth Interventions

Author attribution statement

The chapters of this thesis contain six publications, five of which have been peer-reviewed and published in national and international journals. On all publications, I am the corresponding and lead author.

The author attribution for each chapter is detailed below, using initials: Lyra Egan (LE), Katrina E Champion (KEC), Lauren A Gardner (LAG), Nicola C Newton (NCN), Siobhan O'Dean (SO), Maree Teesson (MT), Laura Ospina-Pinillos (LO-P), Paula Valentina Ballen Alonso (PVBA).

Chapter 2 is under review at *Health Promotion Journal of Australia*. LE led the development of this paper using data from the Health4Life trial. The authors are LE, SO, LAG, NCN and KEC. All authors were involved in conceptualisation. KEC and NCN secured funding for the Health4Life trial. KEC and LAG were responsible for ethics and governance and overall trial administration with oversight from NCN. KEC, NCN, LAG, and SO provided supervision. LE conducted the formal analysis which was verified by SO. LE wrote the original manuscript. All authors were involved in the review, read and approved the final version and agreed to publication.

Chapter 3 has been published in two journal articles. LE led the development of these papers and LE, LAG, NCN and KEC are the authors. First, the protocol for the systematic review has been published in *JMIR Research Protocols*. All authors conceptualised the study. LE wrote the original manuscript. All authors reviewed and approved the final version for publication. Second, the results from the systematic review have been published in *Adolescent Research Review*. LE conducted all article screening, data extraction, and wrote the original manuscript. LAG, NCN and KEC screened a subset of articles. LE and KEC conducted quality appraisal assessments of included studies. All authors were involved in reviewing the original manuscript, read and approved the final version and agreed to publication.

Chapter 4 has been published in *Preventive Medicine Reports*. LE led the development of this paper using data from the Health4Life trial. The authors are LE, LAG, NCN, SO and KEC. All authors were involved in conceptualisation. KEC and NCN secured funding for the Health4Life trial. KEC and LAG were responsible for ethics and governance and overall trial

administration with oversight from NCN. KEC, NCN, and LAG provided supervision. LE developed the methodology and conducted formal analysis and data visualisation with support from SO. LE wrote the original manuscript. All authors were involved in the review, read and approved the final version and agreed to publication.

Chapter 5 has been published in *Health Promotion International*. LE led the development of this paper using data from the Health4Life trial. The authors are LE, LAG, NCN, and KEC. All authors were involved in conceptualisation. KEC and NCN secured funding for the Health4Life trial. KEC and LAG were responsible for ethics and governance and overall trial administration with oversight from NCN. LE developed the methodology and conducted formal analysis. LE wrote the original manuscript. All authors were involved in the review, read and approved the final version and agreed to publication.

Chapter 6 has been published in *Health Promotion International*. LE led the development of this paper. The authors are LE, L-OP, KEC, NCN, PVBA, MT and LAG. All authors conceptualised the study. LE secured funding for this study and acquired ethical approval. L-OP, KEC, NCN, MT and LAG provided supervision. LE, L-OP and PVBA were responsible for data collection and project administration. LE developed the methodology, and LE and PVBA conducted formal analysis and interpretation of data. LE wrote the original manuscript. All authors were involved in the review, read and approved the final version and agreed to publication.

I confirm that all of the work in this thesis is my own, and any contribution made by others has been explicitly acknowledged.

Lyra Egan
12 December 2024

As the supervisors for the candidate upon which this thesis is based, we can confirm that the author attribution statement above is correct.

Dr Katrina Champion	Prof Nicola Newton	Dr Lauren Gardner
12 December 2024	12 December 2024	12 December 2024

Acknowledgements

To anyone reading this, full disclosure: I am writing these acknowledgments in the final days of my PhD, when I am admittedly a little weary (but I promise I had fun too). I intended to jot down thoughts throughout my experience, but like so many "I'll do it later" tasks, it never left the to-do list. While there are undoubtedly moments and people I'll remember only after this is printed, this is my heartfelt attempt to convey my appreciation.

If somebody told me I'd just stepped off the Rotor at Luna Park, I'd believe them; there were moments of fun and moments of terror. But I have profound gratitude that I was surrounded by incredible people who cheered me on every step of the way. While there are far too many people to thank individually, there are some I simply *must* mention.

To my superhero supervisors – Katrina (KC), Nicola (Nickie) and Lauren - your supervision and mentorship was everything I needed and more. Lauren you were a major reason I chose to start this PhD; having you as a supervisor when I started at Matilda made it clear I'd be in excellent hands, and I wasn't wrong. I'm endlessly grateful for your compassionate support, incredible feedback, and the many opportunities you gave me. KC thank you for your calm presence, patience, and insightful ideas. You always listened carefully and reassured and encouraged me to keep going. Nickie thank you for bringing so much positivity, fun, and wisdom. You brought light to challenging moments and always helped me find a way forward when I was stuck. I am in awe of each of you, not only as brilliant researchers, but also with how you manage to juggle your many roles – whether as directors, researchers, mentors, or parents – and still found time for our regular meetings. Your guidance shaped my research and helped me grow beyond measure as a person. I hope to carry forward even a fraction of your brilliance and kindness as I continue my academic career.

To my dear friends and family, I could not have done this without you. To Mum and Dad, my greatest role models: words will never truly capture my gratitude, but I'll try. Thank you for being sounding boards for ideas, practice audiences for presentations, and unwavering pillars of support. To Brett, thank you for being a part of this journey, whether through kind words of encouragement, cookie deliveries or legendary fish curries, your generosity was not lost on me. Pa, thank you for our many chats about "the state of the world"; they were a welcome distraction from the thesis, and I can't wait to celebrate together as the first Dr Egan in the family! These past 3.5 years have been some of the most challenging years for our families,

so thank you all for helping me persevere, even on some really hard days. To the loved ones no longer with us, including Nan, Nanna, and John, who saw me through many chapters of life including parts of this PhD, thank you, I know you'd be proud of this milestone.

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I could write a novel of gratitude, but I'll end with this: I'm thankful beyond words to everyone who nudged me along the way or stood by me. Here's to the future, and whatever adventures come next!

Table of contents

Abbreviations

AIC: Akaike information criterion

APC: Alcohol per capita consumption

ANZCTR: Australian and New Zealand Clinical Trials Registry

ASSAD: Australian secondary school students alcohol and drug survey

BIC: Bayesian information criterion

CONSORT: Consolidated Standards of Reporting Trials

cRCT: cluster randomised controlled trial

FASIII: Family Affluence Scale III

ICSEA: Index of Community Socio-Educational Advantage

K6: Kessler 6-item scale

MHBC: multiple health behaviour change

NSW: New South Wales

OECD: Organisation for Economic Cooperation and Development

OR: odds ratio

PA: physical activity

PR: prevalence ratio

QLD: Queensland

RCT: randomised controlled trial

SD: standard deviation

SES: socioeconomic status

SPANS: Student Physical Activity and Nutrition Survey

SSB: sugar-sweetened beverage

WA: Western Australia

Dissemination, funding, and awards during candidature

1.1 Publications arising from this thesis

1.1.1 Published/ in press

Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E. (2022). eHealth interventions targeting poor diet, alcohol use, tobacco smoking and vaping among disadvantaged youth: Protocol for a systematic review. *JMIR Research Protocols*, 11(5): e35408. **(Chapter 3)**

Egan, L., Gardner, L.A., Newton, N. & Champion, K.E. (2023). A Systematic Review of eHealth Interventions Among Adolescents of Low Socioeconomic and Geographically Remote Backgrounds in Preventing Poor Diet, Alcohol Use, Tobacco Smoking and Vaping. *Adolescent Research Review*, 9(32). (**Chapter 3**)

Egan, L., Gardner, L. A., Newton, N. C., O'Dean, S., & Champion, K. E. (2024). Moderating effects of socioeconomic status and geographical location on the eHealth school-based intervention. *Preventive Medicine Reports*, 46(2): 102855. (**Chapter 4**)

Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E. (2024). Process evaluation of the digital Health4Life intervention among a sample of disadvantaged adolescents and teachers. *Health Promotion International*, 39(6). (**Chapter 5**)

Egan, L., Ospina Pinillos, L., Champion, K. E., Newton, N. C., Ballen Alonso, P. V., Teesson M., & Gardner, L. A. (2024). Adapting the OurFutures Alcohol Module to the Colombian context: A mixed-methods study among Colombian adolescents. *Health Promotion International*, 39(6). (**Chapter 6**)

1.1.2 Under review

Egan, L., O'Dean, S., Gardner, L. A., Newton, N. C., & Champion, K. E. Who reports greater lifestyle risk behaviours? A closer look at sociodemographic differences among Australian adolescents: a cross-sectional analysis. *Health Promotion Journal of Australia*. (**Chapter 2**)

1.2 Additional publications arising during candidature

Garnder, L.A., Rowe, A-L., Newton, N.C., **Egan, L.,** Hunter, E., Devine, E.K., Aitkin, T., Thornton, L., Teesson, M., Stockings, E.*, & Champion., K.E.* (2024). A systematic review and meta-analysis of school-based preventive interventions targeting e-cigarette use among adolescents. *Prevention Science*, 25: 1014-1121. *equally credited senior authors.

Gardner, L.A., O'Dean, S., Rowe, A., Hawkins, A., **Egan, L.,** Stockings, E., Teesson, M., Hides, L., Catakovic, A., Ellem, R., McBride, N., Allsop, S., Blackburn, K., Stapinski, L., Freeman, B., Leung, J., Thornton, L., Birrell, L., Champion, K.E.*, & Newton, N.C.* (2024). E-cigarette use and mental health during early adolescence: An Australian survey among over 5,000 young people. *Australian and New Zealand Journal of Psychiatry*, 58(12). *equally credited senior authors.

Grummitt, L., Bailey, S., Kelly, E., Birrell, L., Gardner, L.A., Halladay, J., Chapman, C., Andrews, J.L., Champion, K.E., Hunter, E., **Egan, L.,** Conroy, C., Tiko, R., Nguyen, A., Teesson, M., Newton, N.C., & Barrett, E.L. (2024). Refining the universal, school-based OurFutures Mental Health program to be trauma-informed, gender and sexuality diversity affirmative, and adhere to proportionate universalism: a mixed methods participatory design process. *JMIR Pediatrics and Parenting*, 7:e54637.

O'Dean, S.*, Smout, S.*, Sunderland, M., Slade, T., Gardner, L. A., Chapman, C., Thornton, L., Osman, B., Hunter, E., **Egan, L.,** Teesson, M., Newton, N. C., & Champion, K. E. (2024). Adolescent behavioural intentions: Secondary outcomes from a cluster randomised controlled trial of the Health4Life school-based lifestyle modification intervention. *Canadian Journal of Public Health*. https://doi.org/10.17269/s41997-024-00955-w *These authors share first authorship.

Egan, L., Riordan, B., Newling, G., Uthurralt, N., & Day, C. (2023). Sydney's inner west is brimming with micro-breweries, should we be worried and what does it mean for research and policy? *Drug and Alcohol Review*, 42(4): 843-847.

Hunter, E., Gardner, L. A., O'Dean, S., Newton, N. C., Thornton, L., Rowe, A., Slade, T., McBride, N., Devine, E. K., **Egan, L.,** Teesson, M., & Champion, K. E. (2023). Peer-related correlates of e-cigarette use in Australian adolescents: A cross-sectional examination.

International Journal of Mental Health and Addiction. https://doi.org/10.1007/s11469-023-01200-0

1.3 Presentations arising from this thesis

Egan, L., Ospina-Pinillos, L., Champion, K.E., Newton, N.C., Ballén Alonso, P.V., Teesson, M., & Gardner, L.A. Innovative and inclusive alcohol prevention: Adapting a digital alcohol prevention program for Colombian adolescents. Oral Presentation at Australasian Society for Behavioural Health and Medicine (ASBHM) 2025 Conference, Gold Coast, Australia, February 5-7 2025 (accepted).

Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E. Relevance and implementation of a universal digital school-based intervention targeting multiple behaviours for a sample of disadvantaged adolescents in Australia. Oral Presentation at Society for Mental Health Research Conference 2024, Sydney, Australia, November 6-8 2024.

Egan, L., Ospina-Pinillos, L., Champion, K.E., Newton, N.C., Ballén Alonso, P.V., Teesson, M., & Gardner, L.A. Innovative and inclusive alcohol prevention: Adapting a digital alcohol prevention program for Colombian adolescents. Poster presentation at Society for Mental Health Research Conference 2024, Sydney, Australia, November 6-8 2024.

Egan, L. "A mixed-methods study among adolescents and teachers in Bogotá, Colombia: Adapting the OurFutures Alcohol Program", Invited presentation for SURCLA (Sydney University Research Community for Latin America) Seminar, Sydney, Australia, August 22, 2024.

Egan, L., O'Dean, S., Gardner, L. A., Newton, N. C., & Champion, K. E. Socioeconomic and geographical factors as moderators of intervention efficacy: Insights from a digital school-based intervention. 3-minute Oral Poster Presentation at International Society for Research on Internet Interventions (ISRII) 12th Annual Meeting, Limerick, Ireland, June 2-5 2024.

Egan, L., Ospina-Pinillos, L., Champion, K.E., Newton, N.C., Ballén Alonso, P.V., Teesson, M., & Gardner, L.A. Shaping the future together: Adapting a digital alcohol prevention program for Colombian adolescents. In Shaping the future together: Co-designing internet-

delivered health interventions for diverse and underserved populations [Symposium] at International Society for Research on Internet Interventions (ISRII) 12th Annual Meeting, Limerick, Ireland, June 2-5 2024.

Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E. Tackling health inequities: a systematic review of eHealth interventions targeting poor diet, alcohol use, tobacco smoking and vaping among disadvantaged adolescents. Oral presentation at Society for Mental Health Research Conference 2023, Perth, Australia, December 1 2023.

Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E. Prevention in diverse contexts: Moderating effects of socioeconomic status and geographical location on the Health4Life intervention outcomes. Oral Presentation at 4th Conference of the Alliance for the Prevention of Mental Disorders, Perth, Australia, November 28 2023.

Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E. A systematic review of eHealth interventions targeting poor diet, alcohol use, tobacco smoking and vaping among disadvantaged adolescents. Oral Presentation at Australasian Society of Behavioural Health and Medicine 2023 Conference, Virtual, Australia, February 8-10 2023.

Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E. Offering disadvantaged adolescents hope for a better future through eHealth interventions targeting poor diet, alcohol use, tobacco smoking and vaping: Findings from a systematic review. Oral Presentation at Digital Health Week 2023 Conference, Virtual, Australia, February 9 2023.

Egan, L., Champion, K. E., Gardner, L. A., & Newton, N. C. eHealth interventions to improve diet, alcohol use, and smoking among rural adolescents: A systematic review. Oral Presentation at The Western NSW Health Research Network (WHRN) 2022 Research Symposium, Dubbo, Australia, October 25 2022.

Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E. Do eHealth interventions targeting poor diet, alcohol use, tobacco smoking and vaping adequately serve adolescents from disadvantaged backgrounds? Findings from a systematic review. 1-Minute Oral Poster Highlight Presentation at Australasian Professional Society on Alcohol and other Drugs (APSAD) Conference 2022, October 10-12 2022.

Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E. Preliminary results from a systematic review on eHealth interventions targeting poor diet, alcohol use, tobacco smoking and vaping among adolescents from disadvantaged backgrounds. Oral Presentation at The Matilda Centre PhD Showcase Seminar, Virtual, Australia, August 4 2022.

Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E. Do disadvantaged youth reap the benefits from eHealth interventions targeting poor diet, alcohol use, tobacco smoking and vaping? Poster Presentation at The Matilda Centre Conference 2022, July 28 2022.

Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E. eHealth interventions targeting poor diet, smoking and alcohol use among disadvantaged youth: A systematic review. Oral Presentation at Australasian Society of Behavioural Health and Medicine 2022 Conference, Virtual, Australia, February 2-4 2022.

Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E. eHealth interventions targeting poor diet, smoking and alcohol use among disadvantaged youth: A systematic review. Oral Presentation at Australia Association for Adolescent Health 2021 Research Showcase, Virtual, Australia, November 23 2021.

1.4 Additional presentations arising during candidature

Egan, L., Newling, G., Uthurralt, N., Riordan, B.C., & Day, C.A. Sydney's inner-west micro-brewery tasting bars and development approvals, fact-based or not? An appraisal of documents submitted to council for development approval. Selected by conference conveners and keynote speakers for a 5-Minute Oral Poster Tour Presentation at Australasian Professional Society on Alcohol and other Drugs (APSAD) Conference 2022, October 10-12 2022.

Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E., Teesson, M. Climate Schools: Universal mental ill-health and substance use prevention programs for adolescents. Oral Presentation at Society for Mental Health Research 2021/22 Conference, Tasmania, Australia, March 24-26 2022.

Egan, L., Gardner, L. A., Newton, N. C., Champion, K. E., & Teesson, M. What about health and wellbeing education for adolescents during lockdown? 'Climate Schools' provides a solution. Oral Poster Presentation at 12th European Society for Prevention Research Conference, Virtual, September 29-Oct 1 2021.

Egan, L., Gardner, L. A., Newton, N. C., Champion, K. E., & Teesson, M. Climate Schools: Supporting evidence-based health and wellbeing education during the COVID-19 pandemic. Oral Presentation at Australian Public Health Conference 2021, Virtual, Australia, September 23-24 2021.

1.5 Research grants arising during candidature

Role	Research team	Project name	Funding body	Grant period	Funding received
Chief Investigator 'A'	**Egan, L.**	Understanding and preventing poor diet, alcohol use, tobacco smoking and vaping among adolescents from low socioeconomic and remoteness areas through eHealth interventions.	Paul Ramsay Foundation	2021-2024	$112,500
Chief Investigator 'A'	**Egan, L.,** Bailey, S., Bryant, Z., de Groot, F., Champion, K.E., Chapman, C., Norman, T.	Vibe Check: Addressing polysubstance use harms among adolescents using an intersectional, youth-led, harm reduction approach.	PREMISE (NHMRC CRE)	2024-2025	$10,000
Chief Investigator 'A'	**Egan, L.**	Engaging with leading eHealth prevention researchers.	The University of Sydney James Kentley Memorial Funds	2024	$3797

Co-investigator	Guckel, T., **Egan, L.,** Bailey, S., Lynch, S.	Queer and trans joy and euphoria as resistance.	The University of Sydney	2022	$2000
Associate Investigator	Champion, K.E., Lubans, D., Newton, N., Baur, L., Teesson, M., Mihalopoulos, C., Gardner, L., Spring, B., Slade, T., Chapman, C., Burrows, T., Thornton, L., Partridge, S., Sunderland, M., Parmenter, B. AIs: Kay-Lambkin, F., Johnson, G., Woolfenden, S., Stockings, E., **Egan, L.**	Health4Life Parents & Teens: a co-designed and scalable eHealth intervention to reduce modifiable cancer risk factors among socio-economically disadvantaged adolescents.	Medical Research Future Fund (MRFF)	2023-2026	$1,624,922
Associate Investigator	Newton, N.,* Gardner, L.,* Teesson, M., Champion, K., Kelly, E., Grummitt, L., Deady, M., Barrett, E., Rowe, A., Birrell, L. AIs: Stapinski, L., Debenham, J., Slade, T., Chapman, C., Kay-Lambkin, F., Mills, K., Sunderland, M., Thornton, L., Stockings, E., **Egan, L.,** Smout, S., Smout, A. *joint lead investigators	OurFutures and Preventure – Taking to scale evidence-based universal and selective prevention programs to improve health and wellbeing and reduce suicidal ideation in male adolescents.	Movember Foundation	2023-2024	$500,000

1.6 Awards arising during candidature

1.6.1 Individual awards

- Travel Award, International Society for Research on Internet Interventions, 2024, $900.
- Professional Staff Development Fund, University of Sydney, 2024, $3287.
- Travel-Grant-in-Aid Award, Society for Mental Health Research, 2023, $1,500.
- Travel & Career Support Scheme Grant, PREMISE (NHMRC CRE), 2022, $5000.
- Tier 3 Covidence Individual Subscription for Systematic Review Protocol, Covidence, 2022 USD$240.
- First Time Presenter Award, The Australian Public Health Conference, 2021, $100.
- PhD Support Scheme, The Matilda Centre, 2021-2024, $2500 per annum.
- Postgraduate Research Support Scheme, 2021-2024, $1000 per annum.

1.6.2 Team awards

Society for Mental Health Research Australian Rotary Health Mental Health Impact Award. OurFutures Team: Newton, N.C., Champion, K., Gardner, L., Rowe, A-L., **Egan, L.,** Hawkins, A., Barrett, E., Birrell, L., Bryant, Z., Chapman, C., Grummitt, L., Hunter, E., Kelly, E., Osman, B., Slade, T., Smout, S., Stapinski, L., Stockings, E., & Teesson, M., 2024.

The Matilda Centre Awards, Outstanding Contribution – Team Award. Diversity and Inclusion Portfolio Team: Gray, M., Rowe, A., Buncuga, A., Guckel, T., Grager, A., **Egan, L.,** Ross, K., Bailey, S., Newman P., Barrett, E., & Stapinski, L., 2023.

Faculty of Medicine and Health Makers and Shapers Award, Diversity and Inclusion – Team Award. Diversity and Inclusion Portfolio Team: Rowe, A.L., Buncuga, A., Gray, M., Guckel., T., **Egan, L.,** Bailey, S., Barrett, E., Newman, P., Ross, K., Stapinski, L., Grager, A., & Routledge, K., 2022.

The Matilda Centre Leonie Manns Community Impact and Engagement Award. OurFutures Team: Newton, N.C., Gardner, L.A., **Egan, L.,** Smout, S., Champion, K.E., Spallek, S., Slade, T., Chapman, C., Conroy, C., Smout, A., Delailomaloma, M., Rowe, A., & Teesson, M., 2022.

Faculty of Medicine and Health Makers and Shapers Award, Outstanding Research – Team Award. Climate Schools Research Team: Newton, N.C., Gardner, L.A., Champion, K.E., Smout, S., Slade, T., Chapman, C., **Egan, L.,** & Teesson, M., 2021.

The Mental Health Services (TheMHS) Mental Health Promotion/Mental Illness Prevention Service and Program Award. Climate Schools Team: Newton, N.C., Gardner, L.A., Champion, K.E., Smout, S., Slade, T., Chapman, C., **Egan, L.,** & Teesson, M., 2021.

1.7 University of Sydney units of study during candidature

- SPAN2622: Latin American Popular Culture – One unit of study, University of Sydney, 2023.
- PUBH5217: Biostatistics: Statistical Modelling – One unit of study, University of Sydney, 2021.

Chapter 1

General introduction

"The greatest wealth is health" – Virgil

1.1. The global prevalence of chronic diseases and their burden

More than six in every 10 deaths worldwide are attributable to chronic diseases (also known as non-communicable diseases), including cardiovascular, respiratory and digestive diseases, diabetes mellitus, and mental health and substance use disorders (WHO, 2024a). The global share of deaths attributed to chronic diseases has remained consistent for decades, with their burden also reflected in disability-adjusted life years (DALY), where one DALY equates to one year of healthy life lost, as a result of disease. Mortality and DALY outcomes due to chronic diseases vary based on country income levels. In high-income countries (e.g. Australia, the United States and Switzerland), chronic diseases have consistently been the leading cause of death (accounting for 76.8% in 2021) (WHO, 2024a) and disability (78.3% in 2021 (WHO, 2024b). In Australia, chronic diseases contribute to approximately 89.6% of all deaths, and 85.5% of DALYs, with approximately 2.6 million years of life lost (YLL) in 2021 (GBD 2019 Australia Collaborators, 2023; WHO, 2024a, 2024b). In 2021-22, approximately 32% of total health expenditure ($48 billion) in Australia was on cancer, cardiovascular diseases, respiratory diseases, mental health and substance use disorders, and endocrine disorders (i.e. diabetes) (Australian Institute of Health and Welfare, 2023). Australia's total health expenditure accounted for 10.5% of the gross domestic product (GDP) (Australian Institute of Health and Welfare, 2023), which is higher than the Organisation for Economic Co-operation and Development (OECD) average of 9.7% (OECD, 2023). However, Australia spends less than 1% of GDP on health prevention (Shiell & Jackson, 2018), perpetuating the cycle of spending on chronic disease treatment.

In contrast to high-income countries, middle- and low-income countries report a greater proportion of deaths and disability due to other causes, such as communicable diseases and injury. For instance, in 2021 chronic diseases accounted for 73.7% of deaths and 71.7% of DALYs in upper-middle-income countries such as Colombia and Türkiye, compared to

around 50% or less in lower-middle-income and low-income countries (WHO, 2024a, 2024b). Colombia, for example, has a rising chronic disease burden, with 57.7% of deaths and 59.8% of DALYs attributed to chronic diseases. While these proportions are lower than in Australia, the total number of deaths and YLL (4.5 million) is higher (WHO, 2024a, 2024b), partly explained by its larger population. Despite Colombia spending 9% of GDP on health expenditure, they experience greater healthcare resource constraints, and unlike Australia, Colombia has not yet achieved universal healthcare coverage (OECD, 2015, 2023; Vergara et al., 2023). This limits Colombia's capacity to effectively address its rising chronic disease burden.

Chronic diseases are also associated with poorer mental health (Huang et al., 2023; Sicouri et al., 2023), and reduced productivity and quality of life; which is exacerbated by experiencing two or more chronic diseases at the same time, commonly referred to as "multimorbidity" (Australian Institute of Health and Welfare, 2020c; Shi et al., 2021). According to the 2022 Australian National Health Survey, one in two (49.9%) Australians had at least one chronic condition, with 28% also reporting comorbid chronic conditions such as cancer, diabetes and stroke (Australian Bureau of Statistics, 2022c). Moreover, the passive experience of caring for someone living with a chronic disease further hinders the collective potential of individual and societal wellbeing, economic growth and sustainable development (Australian Bureau of Statistics, 2022c).

Reducing the prevalence and burden of chronic diseases necessitates several approaches, including protecting people from exposure to modifiable lifestyle risk behaviours. This includes known contributors, such as poor diet, alcohol use and tobacco smoking (GBD 2019 Australia Collaborators, 2023), and emerging risks such as e-cigarette use. It is also critical to provide individuals with wider choices and motivational incentives that focus on nurturing, and ultimately increasing, improved and sustainable health outcomes.

1.2. Modifiable risk factors for chronic diseases

Chronic disease risk is influenced by a multitude of factors, some of which are systemic and hence more difficult to influence, such as individual level of socioeconomic status (SES) or where a person is born and lives (Australian Institute of Health and Welfare, 2024e). However, other factors such as those anchored in lifestyle behaviours may be easier to shift,

as they typically allow individuals to have some control over them, and hence, are modifiable, albeit in the context of their environments. Diet is something that individuals must engage with as an essential part of life, with food choices having the influence to either be health-promoting or disease-contributing (Noce et al., 2021). Conversely, substances such as alcohol and tobacco are non-essential for human functioning, yet, are widespread and engrained in social and cultural norms, particularly in high-income countries such as Australia (Department of Health and Aged Care, 2019), and upper-middle-income countries such as Colombia (Vargas et al., 2021). Nonetheless, poor diet, and alcohol and tobacco use are well-known contributors to chronic diseases such as cancer, diabetes, and cardiovascular and lung diseases (GBD 2021 Risk Factors Collaborators, 2024). The clinical practice guidelines for the Royal Australian and New Zealand College of Psychiatrists (RANZCP) advocate for lifestyle-based approaches such as smoking cessation, limiting alcohol, and promoting a healthy diet for treating mental ill-health, such as depression and distress: in fact, embedding it as a foundational element, prior to commencing any other medication or assessing improved outcomes (Malhi et al., 2021). As such, the impact that these lifestyle risk behaviours have on physical and mental wellbeing is widely recognised. More recently, emerging evidence regarding the health risks of e-cigarette use ("vaping") has sparked urgent attention to addressing this relatively new lifestyle behaviour (Banks et al., 2022; Gardner, O'Dean, et al., 2024).

The peak onset of the aforementioned modifiable lifestyle risk behaviours generally occurs around adolescence. For example, the use of e-cigarettes (vapes), alcohol and tobacco typically begins during adolescence (Degenhardt et al., 2016; Gardner, O'Dean, et al., 2023; Gardner, Stockings, et al., 2024; Guerin & White, 2018) and poorer dietary habits generally increase during adolescence (Australian Institute of Health and Welfare, 2018; Taher et al., 2019). Previous research has described these behaviours as "consumption behaviours", implying that engagement with these behaviours involves a conscious, active choice, to some degree (Thornton et al., 2022). It is also common for these behaviours to co-occur or cluster together (Gardner, Champion, et al., 2022; Papadopoulou et al., 2017; Staff et al., 2020), and track into adulthood (Degenhardt et al., 2008; Viner & Taylor, 2007). Although it may not be immediately visible, adolescents' engagement with each of these behaviours poses risks. Understanding the behaviour-health interplay is crucial for discerning their individual and global public health impact, particularly for youth. The next section will therefore discuss the

trends and harms related to each of these behaviours (i.e. dietary habits, alcohol use, tobacco smoking and vaping), predominantly focusing on youth.

1.2.1. Trends and harms related to adolescent dietary habits

Globally, many children and adolescents report insufficient fruit and vegetable intake, as well as high consumption levels of sugar-sweetened beverage (SSB) and discretionary foods (i.e., non-essential energy-dense and nutrient-poor foods such as fast food), which are key risk factors for poor health (GBD 2017 Diet Collaborators, 2019; National Health and Medical Research Council, 2013; Wallace et al., 2020; WHO, 2018).

In Australia, among children and adolescents aged 2-17 years, approximately 64% meet the Australian fruit intake guidelines (two servings of fruit daily), and only 4% consume sufficient vegetables (five servings of vegetables daily) (Australian Bureau of Statistics, 2022a). As children age, even fewer meet fruit guidelines, while insufficient vegetable intake remains reasonably consistent over the adolescent years (Australian Bureau of Statistics, 2022c). SSBs are the leading source of sugar in Australian diets. The most recent national data show that 7.1% of Australian children aged 2-17 years consume SSBs daily, and 41.1% at least once a week (Australian Bureau of Statistics, 2017-18). Consumption of SSBs increases dramatically with age, from 18.2% of 2-3-year-olds to 57.5% of 14-year-olds, aligning with global patterns of increasing SSB consumption as children age (Lara-Castor et al., 2024). Discretionary food consumption mirrors this age-related trend. According to the latest available data from 2011-2012, discretionary food consumption represented 30% of 2–3-year-olds total daily energy intake compared to 41% of 14-18-year-olds intake in Australia (Australian Bureau of Statistics, 2015). However, as this data is now over a decade old, this may not accurately reflect discretionary food consumption trends, and more recent and representative data is urgently needed.

Poor diet is a significant contributor to global and national chronic disease burden. In 2017, diets low in fruit and vegetables ranked among the top five dietary risk factors for deaths and DALYs, while diets high in SSBs ranked twelfth for deaths and eleventh for DALYs globally. (GBD 2017 Diet Collaborators, 2019). In Australia, poor diet was the third leading risk factor for total disease burden in 2018, accounting for 5.4% (Australian Institute of Health and Welfare, 2021d). This is particularly concerning for children and adolescents, as poor dietary

habits during this formative period increase the risk of developing chronic diseases across their lifespan including digestive issues, heart disease and cancer, and experiencing mental ill-health, such as depression and anxiety (Huang et al., 2019). For example, high SSB consumption places young people at greater risk for increased weight gain, poor dental and bone health, and increased risk of type 2 diabetes (National Health and Medical Research Council, 2013). Reducing the intake of SSBs and discretionary foods among children is one key target area of the National Preventive Health Strategy 2021-2030 (Australian Government Department of Health, 2021). However, several barriers to adopting healthier diets remain, including limited access to affordable, fresh produce in some areas (National Health and Medical Research Council, 2013) (see also section 1.3.2 of this thesis), food reward associated with discretionary food, but not fruit and vegetables (Nansel et al., 2016), and pervasive marketing and affordability of SSBs compared to fruit and vegetables.

1.2.2. Trends and harms related to adolescent alcohol consumption

Another key modifiable lifestyle risk factor is alcohol use. Although no level of alcohol consumption is safe (Anderson et al., 2023; Topiwala et al., 2022), alcohol is a widely consumed and legal (in most countries) psychoactive drug. In 2019, the total global alcohol per capita consumption (APC) was 5.5 litres, representing a reduction of 4.5% since 2010 (WHO, 2024c). However, APC rates vary across countries, with high APC recorded in Australia (10.1 litres) and the United States (9.6 litres), compared to lower APC in countries such as Colombia (4.9 litres) (WHO, 2024c). In Australia, alcohol is one of the most consumed drugs, alongside nicotine (Australian Criminal Intelligence Commission, 2024). Recent national data highlight declines in adolescent alcohol use in Australia. As of 2022-2023, 31% of 14-17-year-olds had consumed alcohol in the previous 12 months, compared to 69% in 2001 (Australian Institute of Health and Welfare, 2024c). Additionally, the average age for first alcohol use in 2019 was 16 years, compared to approximately 14 years two decades ago (Australian Institute of Health and Welfare, 2020d). The delayed onset of alcohol consumption is similar to other high-income countries, such as the United Kingdom and United States. Despite these positive trends, hazardous drinking (often referred to as ‘binge drinking’) remains prevalent. According to the 2022-2023 Australian secondary school students alcohol and drug survey (ASSAD), around half of adolescents who have ever consumed alcohol, drank more than five standard drinks in one episode in the previous month

(Scully, Koh, et al., 2023). In contrast, in upper-middle-income countries such as Colombia, 2019 estimates found alcohol initiation occurred at approximately 13.9 years (National Administrative Department of Statistics. DANE, 2020), with 23.7% of adolescents being current drinkers and 12.4% engaging in binge drinking (WHO, 2024c).

In terms of the global disease burden, alcohol is a significant contributor (GBD 2016 Alcohol Collaborators, 2018; WHO, 2024c), with regular or heavy use associated with serious health concerns – including alcohol poisoning, dependence, mental ill-health, and cancer (WHO, 2024c). In Australia, alcohol use contributed to 4.5% of total disease burden in 2018, making it the fifth leading risk factor (Australian Institute of Health and Welfare, 2021d).

Adolescents are particularly vulnerable to alcohol-related harms, and thus, are advised to abstain entirely from alcohol (National Health and Medical Research Council, 2020). Early initiation, before the age of 18, can alter brain functioning, impact risk-taking (Spear, 2018), and is associated with increased risks of hazardous alcohol consumption and substance use in adulthood (Anderson et al., 2023; Topiwala et al., 2022). Binge drinking among young people also places them at increased risk for accidents, violence, anxiety and depression, as well as cognitive impairments and substance use dependence (Kuntsche et al., 2017; Ning et al., 2020; WHO, 2024c).

1.2.3. Trends and harms related to adolescent tobacco smoking

Tobacco is a plant that contains the highly addictive and psychoactive stimulant nicotine (Benowitz & Schwartz, 2010). Globally, an estimated 21 million people aged 13-15 years report current tobacco smoking, with males consistently reporting greater tobacco use than females (WHO, 2021b). In Australia, fewer young people are initiating tobacco smoking than previous generations. For instance, according to the 2023 ASSAD survey, 13% of 12-17-year-olds reported ever smoking a tobacco cigarette in their lifetime (3% in the past month) compared to 58.1% in 1996 (24.8% in the past month) (Scully, Bain, et al., 2023). This trend in tobacco use among young people is similar to other countries, including the United Kingdom (Breton et al., 2022).

Tobacco control measures, such as those included in the WHO Framework Convention on Tobacco Control adopted by the World Health Assembly in 2003, have largely influenced this decline (WHO, 2003, 2023c). For instance, Australia has implemented more stringent

tobacco control policies since the 1990s, such as: plain packaging, banning smoking in public places, excise tax on tobacco products, tobacco advertising bans, and purchasing age limits (Bonevski et al., 2017; WHO, 2023c).

Despite progress in reducing tobacco smoking, it remains the leading cause of preventable disease globally, accounting for 8 million deaths annually world-wide (GBD 2019 Risk Factors Collaborators, 2020). In Australia, tobacco use was the leading risk factor for total disease burden in 2018, contributing to 8.6% of total burden, and causing 13% (20,500) of attributable deaths and 4.4% of YLD (Australian Institute of Health and Welfare, 2021d). Tobacco cigarettes contain over 7,000 chemicals, including toxic substances such as lead, mercury, cadmium, and carbon monoxide (Benowitz & Schwartz, 2010). Tobacco smoking can lead to dependence after as few as four cigarettes, cancer, diabetes, and heart and lung disease (An et al., 2009; WHO, 2023c). Moreover, tobacco smoking and mental health are closely interconnected: smoking detrimentally impacts mental health and can interfere with the effectiveness of medications to treat mental ill-health (WHO, 2020b) At the same time, adolescents with mental ill-health are more likely to smoke (Lawrence et al., 2015). Adolescents are particularly vulnerable to long-term dependence and brain development changes (Benowitz & Schwartz, 2010). Second-hand, or passive smoke exposure, also poses significant health risks, particularly for children and adolescents, thereby increasing the risk of lung cancer, respiratory issues, and heart disease (WHO, 2023c).

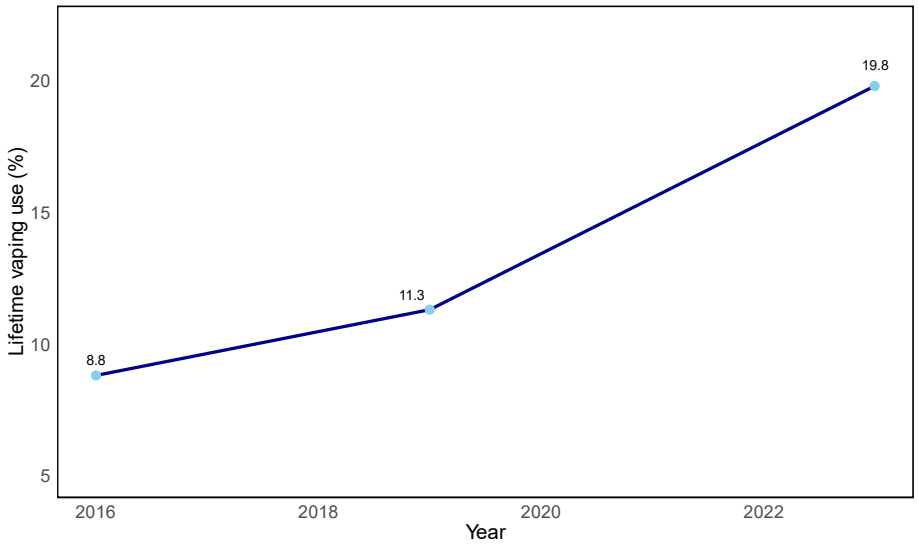
While progress has been made in decreasing the initiation of tobacco smoking among young people, the increased uptake of e-cigarettes may potentially undo years of tobacco control successes in Australia (Freeman, 2023). Indeed, recent research indicates that adolescents who have ever used an e-cigarette are approximately five times more likely to start tobacco smoking, coinciding with the first rising prevalence of current tobacco smoking among adolescents Australia has reported in decades – 2.1% in 2018 to 6.7% in 2022 among 14-to-17-year-olds (Egger et al., 2024).

1.2.4. Trends and harms related to adolescent e-cigarette use (“vaping”)

Electronic cigarette use (e-cigarette use, or “vaping”) refers to battery-operated devices that hold and heat liquids which produce an aerosol mist that the user then inhales (Hiemstra & Bals, 2016). As tobacco smoking has steadily declined over recent years, vaping has

increased around the world. Global estimates report at least 16.8% of young people have ever used an e-cigarette, with 4.8% reporting current use (Salari et al., 2024; Sreeramareddy et al., 2022). In the United States, 27.5% of high school students (approximately 4.1 million) and 10.5% of middle school students (around 1.2 million) reported recent vape use (Wang et al., 2019). In Australia, a recent survey of over 4,000 high school students found that approximately 25% have tried vaping with the mean age of first use at 14 years (Gardner, O'Dean, et al., 2023). In Australia, lifetime use of vaping among those aged 14 and over increased from 8.8% (1.7 million) in 2016, to 11.3% (2.4 million) in 2019, and 19.8% (4.3 million) in 2023 (Australian Institute of Health and Welfare, 2024c), as shown in Figure 1.1. Among current e-cigarette users, the proportion who vaped daily increased from 42.1% in 2019 to 49.3% in 2023.

Figure 1.1. The rising prevalence of lifetime vaping in Australia among people aged 14 and over between 2016 to 2023



E-cigarettes contain hundreds of chemicals, many of which are toxic: such as metals including cadmium and lead, and volatile organic compounds such as propylene glycol, and may or may not contain nicotine, with those labelled as nicotine-free often still containing nicotine (Cheng, 2014; WHO, 2023c). Vaping has been promoted as a safer alternative to tobacco cigarette smoking, and recommended as a smoking cessation tool among adults (Cobb & Abrams, 2014; Glynn et al., 2021). However, research suggests vaping can negatively impact quit attempts (Gmel et al., 2016; Zawertailo et al., 2017), and may have a higher dependency potential than tobacco cigarettes (Jankowski et al., 2019). While the long-term effects of vaping remain inconclusive, e-cigarette use increases the risk of lung damage, burns from faulty devices, and developing nicotine dependence (Banks et al., 2022; Besaratinia & Tommasi, 2020; Seitz & Kabir, 2018).

Among young people, vaping is associated with poorer mental health, including depression (Gardner, O'Dean, et al., 2024), as well as a three- to five-fold increase in the likelihood of initiating tobacco smoking (Egger et al., 2024; Yoong et al., 2021). Dual use of both vaping and tobacco smoking is also common among young people (Wakefield et al., 2023). Given that many of these young e-cigarette users have never smoked traditional cigarettes, the potential long-term health risks make vaping a critical public health concern.

Most high-income countries (84%) have e-cigarette sales bans or regulatory measures (e.g. plain packaging, banning the use of flavours) (WHO, 2023c), which have been shown to decrease young people's interest in trying them (Moodie et al., 2022). In early 2024, the Australian Federal Government introduced stricter regulations such as limiting legal vape sales to pharmacies for smoking cessation purposes only (Parliament of Australia, 2024). However, such approaches to date, have had limited impact in addressing illegal supply and demand of e-cigarettes (Gartner, 2023), thus highlighting the importance of equipping young people with the knowledge they need to make informed health choices (Stockings et al., 2024).

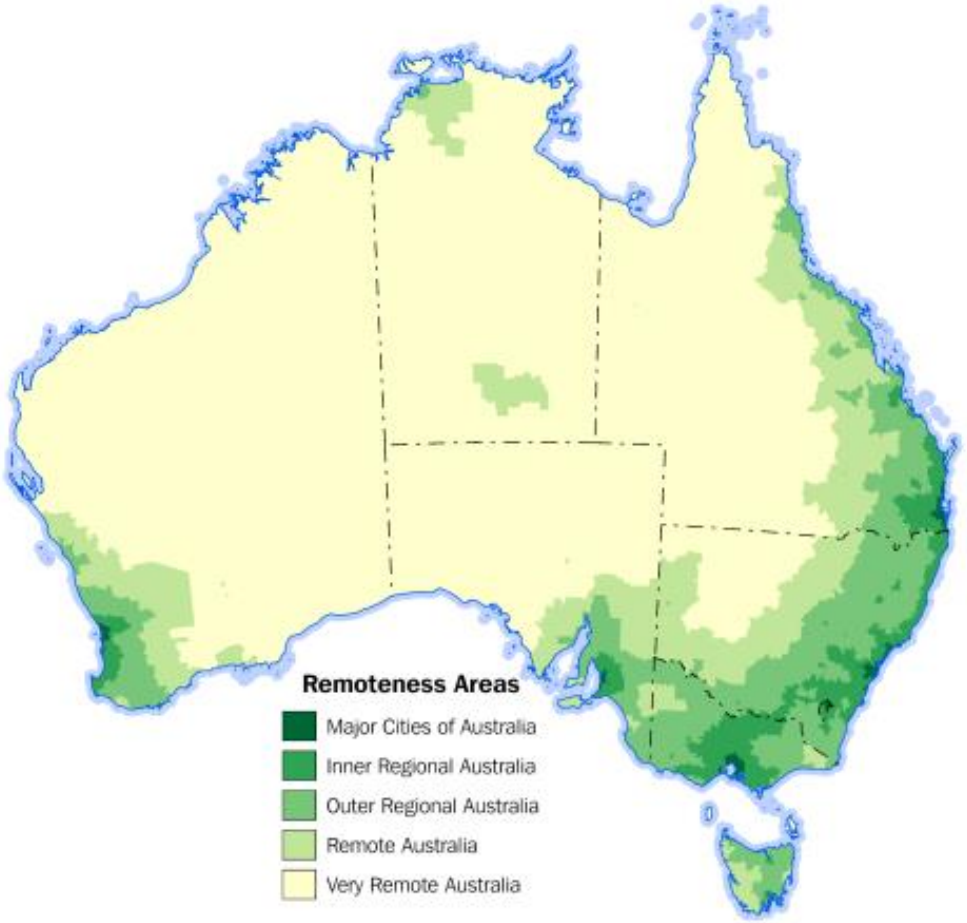
1.3. Disproportionate prevalence and burden on disadvantaged populations

"*Health inequities arise from the conditions in which people are born, grow, live, work, and age and inequities in power, money, and resources that give rise to these conditions of daily life."* (Marmot et al., 2012)

There is unequivocal evidence supporting the role of social determinants on health outcomes, including cancer, substance use disorders, and mental illness (Marmot & Bell, 2019; Massouh et al., 2023). These social determinants refer to the contexts underlying where a person is born, raised, lives, and works, including their access to healthcare (Commission on Social Determinants of Health, 2008; Flavel et al., 2024; Spencer et al., 2019; R. M. Viner et al., 2012). They are referred to as the 'upstream factors', and account for approximately 30% to 55% of health outcomes, and influence health inequities, where we see a social gradient in health and illness (Australian Institute of Health and Welfare, 2024a; WHO, 2023b). A key example of the social inequalities mediating poor health is found in the disproportionate prevalence of chronic disease burden among populations living in lower SES and/or geographically remote areas, both within and between countries (Australian Institute of

Health and Welfare, 2019a, 2024a; Goeres et al., 2016; Niessen et al., 2018; Raju et al., 2020; Talens et al., 2021). SES is commonly understood as a person's position in the social hierarchy based on factors such as: their highest attained level of education, income, and social class (Darin-Mattsson et al., 2017). Whereas, geographically remote areas are defined as locations situated outside of major cities, typically further removed from infrastructure and essential services. Internationally, these areas are commonly referred to as 'rural' or 'remote'. In Australia, the term 'regional' is also used, with the Australian Statistical Geography Standard (ASGS) classifying geographically remote areas based on access to goods and services, according to the following categories: *Inner regional, Outer regional, Remote,* or *Very remote,* as shown in Figure 1.2 (Australian Bureau of Statistics, 2023).

Figure 1.2. Australian Statistical Geography Standard (ASGS) of remoteness areas for Australia (Australian Bureau of Statistics, 2023)



In 2022, the prevalence of having at least one chronic condition was greater among people living in the most disadvantaged (53.7%), compared to least disadvantaged (43.9%) areas of Australia. This is also true for 'inner regional' populations (56.9%) and 'outer regional' and 'remote' areas (56.9%), when compared to people living in major cities (47.5%) (Australian Bureau of Statistics, 2022c). The prevalence of having two or more chronic conditions (multimorbidity), also follows this trend. This is not exclusive to Australia, with other high-income countries reporting similar sociodemographic differences in multimorbidity (Hernández et al., 2021; Low et al., 2019; Moin et al., 2021; Pache et al., 2015; Ryan et al., 2020).

These health inequities are systemic, unfair, and avoidable (McCartney et al., 2019). Indeed, the 2018 Australian Burden of Disease Study estimated that 42.1% of the DALYs attributed to cardiovascular diseases in the most disadvantaged groups could have been avoided if their burden had been equal to that of the most advantaged groups (Australian Institute of Health and Welfare, 2021d). Similarly, 49.1% of the total DALYs attributed to cardiovascular diseases for remote and very remote areas could have been prevented if they had the same rate of burden as people from major cities. Living with a chronic condition adds to the existing health and social burden disadvantaged populations already experience (e.g. financial, social issues) (Van Wilder et al., 2021).

Both low SES, and living in a geographically remote area, independently contribute to poorer health outcomes. However, these factors can also intersect and share similar barriers to health equity. For instance, these populations may experience stigma (Robards et al., 2018), report lower education and health literacy levels, have limited employment opportunities, face challenges affording health services (Hernández et al., 2021; Low et al., 2019; Moin et al., 2021; Ryan et al., 2020), and accessing skilled healthcare workers, especially outside of major cities (WHO, 2021c). Adolescents from disadvantaged contexts also face unique barriers to health, including that they are: more likely to be exposed to lifestyle risk behaviours; have greater stressors impacting their health; experience poorer mental health (Australian Institute of Health and Welfare, 2020a, 2021a); and are more susceptible to later chronic diseases. The future life trajectory for those who go on to live with a chronic disease is heavily impacted, subsequently adding to health and social inequities.

1.4. Adolescence - the foundation of future health

Adolescence is defined as a key developmental period – typically spanning ages 10 to 19 years – that bridges childhood and adulthood (Sawyer et al., 2018). As a specific demographic, adolescents constitute approximately 16% of the global population (WHO, 2023a). Whilst in Australia, there are more than 3.2 million adolescents (approximately 12.2% of Australia's population in 2020) (Australian Institute of Health and Welfare, 2021a). Marked by immense physical, cognitive, social and emotional development, as well as greater independence and autonomy, adolescence is a time of burgeoning growth in the human condition. Although concomitantly, this developmental period is often accompanied by increased exposure to physiological and mental health risks, that can shape health behaviour and outcomes in adulthood: including lifestyle risk behaviours mentioned in the previous sections (Sawyer et al., 2012; Spear & Kulbok, 2004). Thus, preventing or modifying engagement with these lifestyle risk behaviours during adolescence is critical for reducing chronic disease risk, and associated burdens (at both an individual and societal level), in adulthood.

Adolescence is also a key period when social determinants can have long-lasting impact on health outcomes. Indeed, early life disadvantage can influence health risk in adulthood (Yang et al., 2020) and health and educational challenges (Villadsen et al., 2023). Therefore, establishing healthy habits during adolescence is critically important to circumvent the widening gap in health equity. Disadvantaged adolescent populations comprise a considerable segment of global population. In Australia, approximately 25% of people aged 15 to 24 years (814,000) live outside of major cities (Australian Institute of Health and Welfare, 2021a); and 15% (464,000) live in low-income households (Australian Institute of Health and Welfare, 2021e). Given the size of these cohorts, it is imperative that effective health education and prevention approaches reach and benefit them, to mitigate widening health equity for current and future generations. Important to this, is understanding how lifestyle risk behaviours manifest across diverse sociodemographic groups in Australia to better inform appropriate prevention approaches that meet the needs of all adolescents.

1.5. Trends and harms of lifestyle behaviours among disadvantaged youth

There is substantial research indicating that lifestyle risk behaviours, such as poor diet, alcohol use, tobacco smoking and vaping, are more prevalent among disadvantaged populations than their more advantaged counterparts. Whilst these disparities occur across the lifespan, this section will focus on this specifically in youth as it is a critical period for establishing behaviours that can influence long-term health outcomes.

1.5.2. Trends and harms related to dietary habits in disadvantaged youth

Adolescents with lower SES in most developed countries are less likely to consume fruit and vegetables daily than higher SES adolescents (WHO, 2020a). According to the most recent national data of Australian children and adolescents aged 5-14 years from 2017-18, those from low SES areas were more likely to report insufficient fruit intake (37% vs. 26% in higher SES areas) and more likely to consume SSBs weekly (53% vs. 33%) (Australian Institute of Health and Welfare, 2022). The 2017-18 data did, however, report similar levels of fruit and vegetable intake, and SSB consumption, by geographical location. On the other hand, there is a lack of recent national data specifically reporting on discretionary food consumption by SES and geographical location. Findings from smaller-scale studies thus provide insights into differences. While not directly comparable, as different study samples were analysed, Niven et al. (2014) reported greater discretionary food consumption among adolescents of low SES compared to high SES, whereas Scully et al. (2020) reported lower discretionary food consumption among adolescents located in rural and remote areas, compared to major cities.

Given that dietary habits formed in adolescence often continue into adulthood, these inequalities in diet quality have concerning implications for long-term health outcomes. Particularly considering that diet-related outcomes such as dental decay, being overweight or obese are more prevalent among adolescents from low SES areas and living in remote to very remote areas, than high SES areas and major cities, respectively (Australian Institute of Health and Welfare, 2020a).

1.5.3. Trends and harms related to alcohol use in disadvantaged youth

The relationship between alcohol use, SES and geographical location among adolescents is nuanced. According to a 2020 World Health Organisation Report, adolescents of higher SES generally report higher lifetime and current alcohol use, than those of lower SES (WHO, 2020a). Whereas studies from the United States and across Europe report higher alcohol consumption among lower SES and geographically remote-residing ('rural' and 'remote') adolescents (Coomber et al., 2011; Shackleton et al., 2019).

In Australia, national survey data reveal that 42% of rural and remote adolescents aged 12-17 reported alcohol use in the past year, compared to 28% in major cities, with rural and remote adolescents being more likely to obtain their first and current alcohol from parents than those in major cities (Chan et al., 2015). Risky drinking, such as binge drinking, is also more prevalent among adolescents from lower SES backgrounds. Australia's Children Report shows that 2.2% of 12-14-year-olds in low-income areas engage in binge drinking compared to 0.1% in the highest-income (Australian Institute of Health and Welfare, 2020a). Similarly, high-risk alcohol consumption also appears to increase with remoteness (greater distance from major cities), with one Australian study from Victoria reporting 26.5% of adolescents from 'outer regional or remote' compared to 19.8% in major cities reported risky drinking (Livingston et al., 2008). Disadvantaged adolescents are vulnerable to experiencing greater alcohol-related harm despite similar levels of alcohol consumption to their more advantaged peers (Roche et al., 2015; Tolstrup et al., 2023).

1.5.4. Trends and harms related to tobacco smoking in disadvantaged youth

Globally, studies in adolescents of low SES and geographically remote contexts show that they are more likely to smoke than their more advantaged peers (Coomber et al., 2011; Moor et al., 2015). In Australia, national data collected in 2017 showed that adolescents aged 12-14 years living in the lowest SES areas had a smoking prevalence more than twice that of their peers in the highest SES areas (2.9% versus 1.4%) (Australian Institute of Health and Welfare, 2020a). Similarly, research consistently demonstrates higher tobacco smoking prevalence among rural and remote adolescents compared to those in major cities (Coomber et al., 2011; Lutfiyya et al., 2008). However, much of this data is outdated: the data from Coomber et al. (2011) and Lutfiyya et al. (2008) is from over a decade ago. Therefore, more

current research on adolescent tobacco smoking behaviour in Australia by SES and geographical location is needed to inform prevention efforts.

Tobacco smoking among disadvantaged adolescents exacerbates existing inequalities. It significantly increases their risk of experiencing tobacco smoking-related chronic diseases later in life such as chronic obstructive pulmonary disease (COPD) and diabetes, which disproportionately affect disadvantaged populations (Australian Institute of Health and Welfare, 2024a; Nichols et al., 2024). Smoking and mental health outcomes also intersect, – for example, the prevalence of past 30-day tobacco smoking among Australian adolescents is higher (24.4%) among adolescents with major depressive disorder, than those without (4.1%) (Lawrence et al., 2015) – with bidirectional effects between smoking and depression among adolescents reported (Chaiton et al., 2009). Thus, smoking potentially worsens the already poorer mental health outcomes they experience compared to their more advantaged peers (Australian Institute of Health and Welfare, 2020a, 2021a). Additionally, adolescents from disadvantaged backgrounds are disproportionately exposed to second-hand tobacco smoking, with 4.4% of lowest SES compared to 0.8% of highest SES households, and approximately 3.8% across inner-, outer-regional and remote/very remote compared to 2.2% of major cities (Australian Institute of Health and Welfare, 2020a). This second-hand exposure increases their risk of experiencing respiratory diseases and likelihood of initiating tobacco smoking (Leonardi-Bee et al., 2011; WHO, 2023c), thereby perpetuating intergenerational cycles of tobacco use dependence.

1.5.5. Trends and harms related to vaping in disadvantaged youth

Global trends in vaping among adolescents from disadvantaged contexts appear to differ from dietary habits, alcohol use and tobacco smoking patterns discussed in the previous sections. Research from the United Kingdom, United States, and Germany indicate a greater prevalence of e-cigarette use among low SES and geographically remote adolescents than their more advantaged peers (Dai et al., 2021; Green et al., 2020; Hanewinkel & Hansen, 2024). However, recent Australian data shows a dissimilar trend. In 2022-2023, the prevalence of current e-cigarette use among people aged 14 and over, was lower among individuals in the lowest SES group (5.8%) compared to the highest SES group (8.7%) (Australian Institute of Health and Welfare, 2024c), with little differences across geographical

locations. However, it is crucial to note that, these figures reflect trends across the entire population aged 14 and over, and may not accurately capture e-cigarette use among adolescents specifically. The potential harms related to vaping could disproportionately affect disadvantaged youth, much like tobacco smoking. However, to our knowledge research on this topic is lacking, yet needed to fully understand the extent to which disadvantaged adolescents experience these harms compared to their more advantaged peers.

1.6. Prevention

Across society, chronic diseases are largely preventable, thus highlighting the importance of effective prevention approaches. In this context, prevention refers to strategies aimed at avoiding or reducing the risk of chronic diseases, such as promoting healthy lifestyles and health education. Primary prevention, which seeks to modify existing risk factors to encourage protective health behaviours is particularly cost-effective for society long term, as it alleviates the need for costly treatments and associated burden on the individuals, carers, and healthcare systems (Australian Institute of Health and Welfare, 2020b). This is particularly true for disadvantaged populations who may experience financial or logistical barriers to accessing treatment.

Prevention also supports healthier populations in general, and generates longer-term benefits, such as increased lifespan, and better quality of life (The Department of Health and Aged Care, 2021). The evidence supporting an association between lifestyle risk behaviours (such as poor diet, alcohol use, tobacco smoking and vaping) and chronic diseases, reinforces the potential opportunity for behaviour change to alleviate the incidence of chronic diseases. Prevention is not only about avoiding illness, but also about promoting long-term health and wellbeing for the population. Despite this, Australia spends less than other high-income countries on prevention (Shiell & Jackson, 2018).

International voices are growing louder in their expectation and need for concerted preventive action, to address the growing burden of chronic diseases. In 2011, 2014 and 2018, The United Nations held high-level meetings on this issue, and called for international commitments to prevent chronic disease-associated morbidity and mortality, via targets and action plans (Beaglehole et al., 2011; United Nations, 2014, 2018). These are reflected in the United Nations 2030 Agenda for Sustainable Development (United Nations, 2015),

particularly under Sustainable Development Goal (SDG) 3 which aims to: “Ensure healthy lives and promote wellbeing for all at all ages”. Key targets include reducing premature mortality from chronic diseases, via prevention (Goal 3.4); and strengthening efforts to prevent substance use including hazardous alcohol consumption (Goal 3.5). Australia’s National Preventive Health Strategy 2021-30 integrates the broader objectives of SDG 3 into this national framework focused on preventing long-term ill health, and improving overall health outcomes (Australian Government Department of Health, 2021). The National Preventive Health Strategy endorses promoting healthy lifestyle behaviours – such as healthy diet, tobacco cessation and alcohol consumption, which is consistent with the United Nation’s SDGs, and highlights the importance of lifestyle behaviours in chronic disease prevention.

Minimising or eliminating engagement in these lifestyle risk behaviours could have reduced the total disease burden in Australia in 2018 by 38% (Australian Institute of Health and Welfare, 2021c). Adolescence represents a critical window of opportunity to intervene – before these behaviours become entrenched – as lifestyle risk behaviours are typically first established during this period. Indeed, evidence supports the positive impact of engaging in health-promoting behaviours during adolescence, when correlated with adolescent and adult health outcomes (Liu et al., 2012). This early prevention is particularly important for disadvantaged populations, who are more vulnerable to exposure to, and adoption of, lifestyle risk behaviours. These lifestyle risk behaviours are underlying contributors to health inequities, and thus, are crucial targets for prevention strategies (Marmot et al., 2012; Solar & Irwin, 2010). Early and effective prevention can mitigate the escalation of health issues and reduce health disparities for these populations. Prevention, therefore, benefits public health and reduces health inequities.

However, the type and mode of prevention delivered is important, for achieving the best overall outcome. Depending on the target populations’ level of risk, different prevention approaches may be appropriate, including: (a) universal (delivered to the entire population regardless of level of risk); (b) selective (delivered to sub-groups who are deemed to have characteristics leading to greater risk, e.g. due to behavioural, environmental, and genetic factors); or (c) indicated (delivered to sub-groups who demonstrate high-risk factors, and have not yet developed the chronic disease) (Cuijpers, 2003; Jairath et al., 2019). A further concept of (d) proportionate universalism, leverages universal and selective prevention approaches, and advocates for prevention that is proportionate to the level of need, without the exclusion or stigmatisation that may occur in selective approaches (Carey et al., 2015).

Having said this, to date, published evidence on the real-life practical applicability of proportionate universalism is limited.

1.6.1. Universal prevention

Universal prevention approaches are population-based. They are designed to reduce the risk of disease across an entire population, and are delivered broadly, notwithstanding individual levels of risk (e.g. an intervention targeted across all secondary school students, aimed at preventing lifestyle risk behaviours such as poor diet, alcohol use, tobacco smoking and vaping). A key advantage of universal prevention is the ability to reach large numbers of people at a relatively low cost, when compared to selective approaches. Despite the strengths of universal prevention, there are challenges in ensuring such approaches adequately reach and benefit disadvantaged adolescents.

Schools provide an ideal environment for implementing universal prevention programs, as they allow access to a large proportion of adolescents in a structured learning environment. However, for disadvantaged adolescents – including those from low SES and/or geographically remote backgrounds, participation in, and benefits from in-person programs, may be hindered by lower school attendance, limited access to adequate and relevant programs, and financial barriers (O'Hara et al., 2021). Thus, improving participation rates in prevention interventions for disadvantaged adolescents requires consideration of social, structural, and economical barriers they experience (Alliott et al., 2022).

School-based digital or electronic health (eHealth) interventions delivered via mobile-, computer-, web-, or telephone-based programs, offer a unique opportunity to bridge these gaps, and make prevention more inclusive. As adolescents are high users of technology (Patton et al., 2016; Vogels et al., 2022), and 95% of Australians have internet access (World Bank Group, n.d.), most adolescents regardless of their socioeconomic or geographical context, can access these interventions. Compared to traditional face-to-face interventions, eHealth interventions confer several key benefits: including, cost-effectiveness; scalability to reach more of a target population; flexibility in accessing evidence-based content; and improved engagement and fidelity (Newton et al., 2017).

While evidence drawn from systematic reviews has supported the effectiveness of eHealth interventions in preventing lifestyle risk behaviours such as poor diet, tobacco smoking and

reducing alcohol use among adolescents in the general population (A. Hutton et al., 2020; Kazemi et al., 2021; Kemp et al., 2021; Taylor et al., 2017), when applied to school-based cohorts, a meta-analysis of eHealth interventions targeting multiple risk behaviours reported their limited effectiveness regarding alcohol, tobacco and certain diet components (SSBs, fat, snacks) (Champion, Parmenter, McGowan, Spring, Wafford, Gardner, Thornton, McBride, Barrett, Teesson, & Newton, 2019). Although, additional studies reporting on the outcomes of multiple health behaviour change (MHBC) interventions have been published since this meta-analysis, thus further investigation into their efficacy is needed. As an example, findings from the mobile health (mHealth) school-based intervention, *SmartCoach*, targeting substance use (alcohol, tobacco and cannabis use), wellbeing and social skills, reported its effectiveness in reducing tobacco and cannabis use at 18-months follow-up, with limited effect on alcohol use (Castro, Haug, Wenger, & Schaub, 2022). The authors suggested this result was potentially due to the social acceptance of alcohol compared to other substances, highlighting the importance of targeting social norms. It is worth mentioning that at the 6-month follow-up, the intervention significantly reduced the quantity of alcohol and tobacco use (Haug et al., 2021). Moreover, participants who engaged more frequently with *SmartCoach* had lower odds of tobacco smoking and those who read SMS messages more attentively were less likely to report problem drinking (Castro, Haug, Debelak, et al., 2022). Thus, demonstrating the importance of designing interventions that facilitate active engagement and attention to facilitate long-term intervention effects. It is also worth noting that much of the current evidence has focused on the general population. Moreover, when it comes to vaping, there has been scant evidence on the efficacy of school-based eHealth interventions in general. For instance, in Australia there is the universal school-based eHealth *OurFutures Vaping Study*, however, the findings have not yet been published (Gardner, Rowe, et al., 2023). Thus, there is a knowledge gap in the synthesis of the effectiveness of eHealth interventions targeting poor diet, alcohol use, tobacco smoking and vaping among disadvantaged adolescents.

Furthermore, although universal interventions will ideally be received equally by participants – regardless of sociodemographic contexts, the unique barriers confronting disadvantaged adolescents may impact their participation rates, and the subsequent effectiveness of the intervention. This may include whether SES and geographical location influence the effectiveness of universal interventions. Therefore, intervention program design should consider the specific needs of disadvantaged adolescents, to promote more effective

engagement (Yardley et al., 2016). In this regard, ensuring that programs are affordable, accessible, and user-friendly, and also address potential gaps in participants' digital literacy by incorporating appropriate supporting measures to enable their engagement. In reality, understanding these needs requires in-depth process evaluation of such programs, to ascertain whether SES and geographical location influence program implementation, and to detect any barriers and facilitators to participation (Moore et al., 2015). Ideally, process evaluations should be conducted using well-established measures. For instance, Newton et al. (2021) recommend five concepts for evaluating user experience (acceptability, satisfaction, perceived impact, credibility and usability). Understanding this is key to identifying any challenges disadvantaged adolescents may experience, alongside any areas for refinement, to optimise acceptability, engagement, and overall impact (Ellard & Parsons, 2010). However, few recent process evaluations of school-based eHealth interventions have been conducted among disadvantaged adolescents.

Nevertheless, global scalability remains a key advantage of eHealth interventions. Once proven effective at driving behaviour change in one context, they may be adapted to other countries facing similar public health challenges, via the application of appropriate place-based end-user co-design methods. This not only delivers significant benefits on intervention engagement and outcomes, thanks to end-user involvement (Slattery et al., 2020), but it also removes the need to repeat the costly and resource-intensive process of developing entirely new interventions. This is particularly valuable in lower-resource settings, where there may be limited capacity to develop and roll out new evidence-based interventions. For instance, in upper-middle-income countries such as Colombia, where alcohol consumption among adolescents initiates at an earlier age than in Australia (approximately 13.9 years versus 16 years) (Australian Institute of Health and Welfare, 2020d; National Administrative Department of Statistics. DANE, 2020) – and sociodemographic disparities in alcohol consumption and health burdens exist –, there is a shortage of school-based standardised alcohol prevention programs, with no existing school-based eHealth interventions targeting alcohol use, among adolescents. Adapting successful evidence-based programs from other contexts, may be a viable and cost-effective approach to address health concerns, particularly for disadvantaged adolescents. However, it is critical to first understand the local context, to ensure any proposed intervention aimed at effectively addressing health behaviours also aligns with local norms, language, and values. Despite the potential, there is limited evidence on the acceptability and effectiveness of universal school-based eHealth interventions

developed in high-income countries such as Australia, when applied in upper-middle-income countries such as Colombia. One program that shows promise in addressing these gaps is the universal, Australian, *OurFutures prevention model.*

1.7. Introducing the Australian OurFutures suite of prevention programs and the Health4Life intervention

1.7.1. OurFutures development and content

The *OurFutures prevention model* (previously known as *Climate Schools*) has informed the development of a suite of internet-based programs designed to prevent substance use and mental ill-health among secondary school students. The *OurFutures* model was created to overcome common implementation barriers for the delivery of high-quality prevention programs while addressing the urgent demand for early substance use prevention programs (Newton et al., 2020; Newton et al., 2009; Vogl et al., 2012). Developed by Australian university researchers and supported by both government and philanthropic funding, the *OurFutures* model was created through collaboration with students, teachers, and education experts. Since 2002, the *OurFutures* model has been continuously refined to meet the evolving needs of adolescents. Currently, there are five publicly available modules including: Alcohol (Year 8; in Australia aged 13-14 years); Alcohol & Cannabis (Years 8 & 9); Cannabis & Psychostimulants (Years 9, 10 & 11); MDMA & Emerging Drugs (Years 10 & 11) and Mental Health (Years 8, 9 & 10). Each module consists of four to six 40-minute online lessons delivered during regular health education classes. Underpinned by a comprehensive social influence and harm minimisation approach to prevention, the core evidence-based information for each lesson is delivered via 20-minute online cartoon comics, with characters approximately the same age as the target students (example Figure 1.3). The comics integrate relatable topics such as teenage drama and love interests to maintain student engagement and interest. Each lesson is supported by a range of optional teacher-facilitated activities, quizzes, and summary sheets for students, teachers and parents to reinforce the core content. The lessons are mapped to the Australian National Health education curriculum and have accompanying implementation guides meaning no formal teacher training is required.

Figure 1.3. Example slides from the OurFutures cartoon-based lessons

1.7.2. OurFutures evidence base

The *OurFutures* modules have undergone rigorous evaluation via eight large cluster randomised controlled trials (RCT) in Australia including over 21,000 students from 240 schools. These trials have demonstrated that universal eHealth programs based on the *OurFutures* model can be effective in targeting substance use and mental health among young people, offering an alternative to traditional face-to-face health education. Specifically, the modules have shown success in preventing the initiation and harmful use of alcohol and other drugs, reducing substance use-related harms, slowing the progression of anxiety symptoms, reducing psychological distress and depression, and improving attitudes towards alcohol among adolescents (Newton et al., 2020; Slade et al., 2020). Additionally, at age 20 (7 years post-intervention) reductions in harmful alcohol use were still observed (Newton et al., 2022). The model materials have been adapted for use in several countries including the United Kingdom (Newton et al., 2014) and Germany (Röhrig et al., 2023), suggesting strong potential for the successful global scalability of the *OurFutures* model.

1.7.3. Health4Life development and content

Built on the successful *OurFutures prevention model*, the *Health4Life Initiative* is the first eHealth intervention to concurrently target six lifestyle risk behaviours, namely poor diet, alcohol use, tobacco smoking, physical inactivity, sedentary recreational screen time, and poor sleep (Champion et al., 2020; Teesson et al., 2020). Developed between 2018-19 via co-design methods, *Health4Life* was created by researchers based at Australian universities in collaboration with school students and teachers. Following the same structure as the *OurFutures* modules, *Health4Life* includes six 40-minute online lessons delivered to Year 7 (approximately 12-13 years) students during their regular health education classes. Students ideally complete one lesson per week. Each lesson is guided by social influence, social cognitive, and self-determination theories to promote healthy behaviour change. The central component of the program is the cartoon comics which deliver evidence-based information on the six lifestyle risk behaviours via characters the same age as the target students (example Figure 1.4). Additional behaviour change techniques are embedded within the comics including those to build resistance skills, promote normative education and encourage autonomous motivation (Michie et al., 2015). Each lesson is supplemented by quizzes (example Figure 1.5), summary sheets for students and teachers (example Figure 1.6), and a variety of optional teacher-led activities (e.g. worksheets and homework activities; example Figure 1.7). Additionally, students have access to a companion smartphone app, which provides further resources and support (Thornton et al., 2021).

Figure 1.4. Example slides from the Health4Life cartoon-based lessons

Figure 1.5. Example quiz from the Health4Life cartoon-based lessons

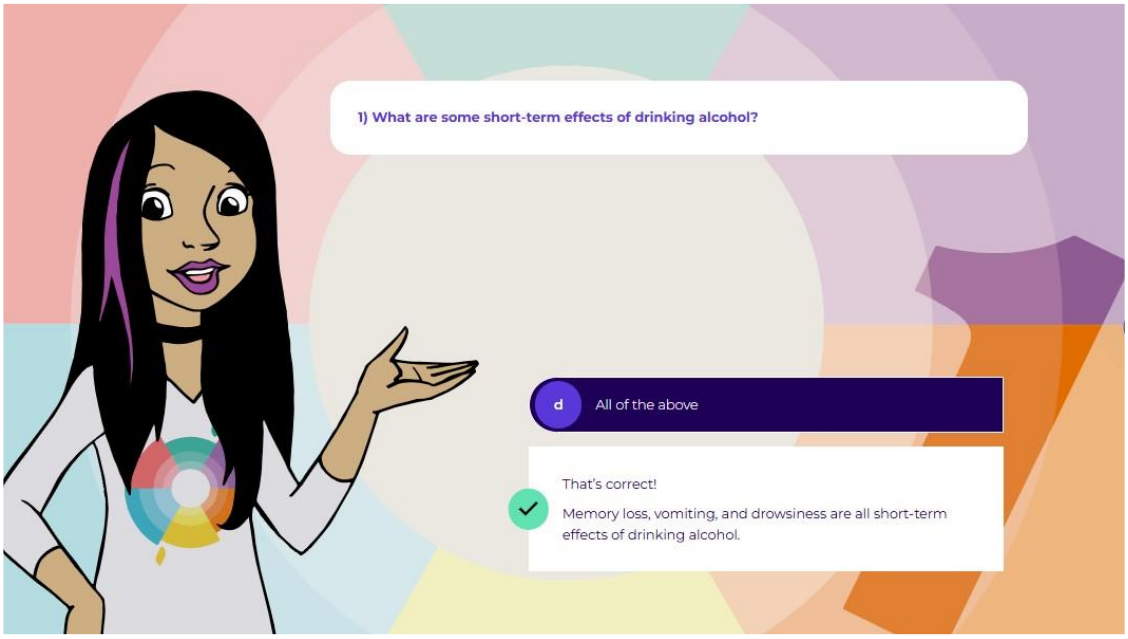


Figure 1.6. Example summary sheets for students and teachers from the Health4Life cartoon-based lessons

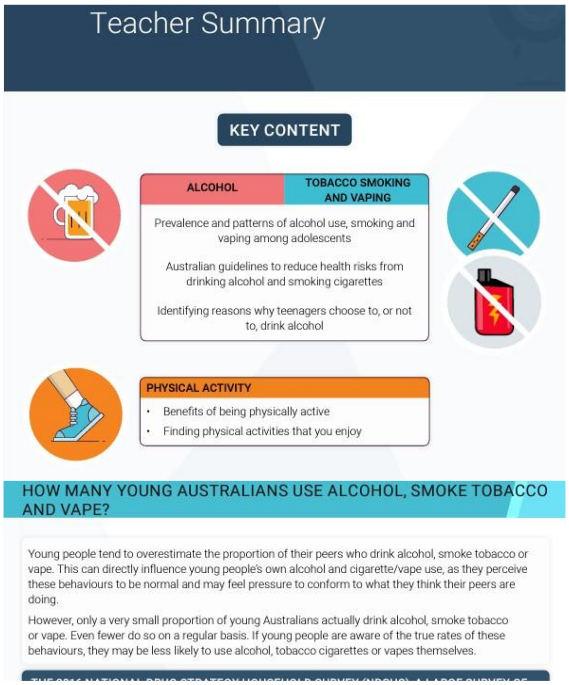
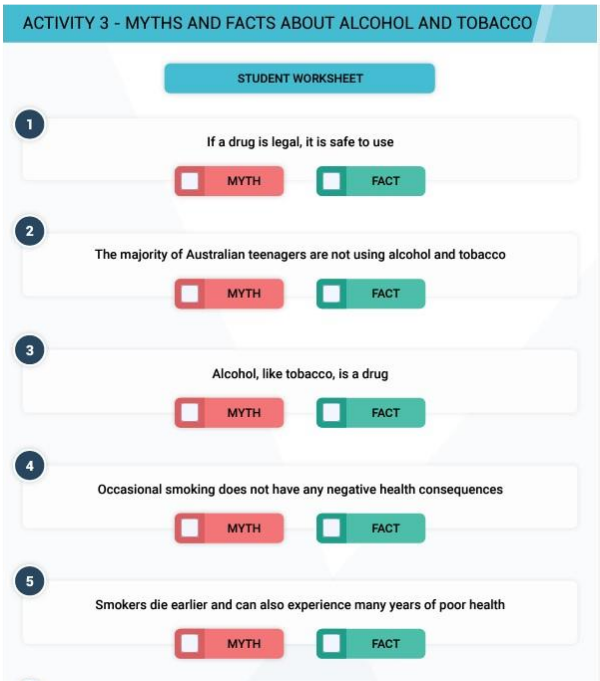


Figure 1.7. Example activities from the Health4Life cartoon-based lessons



1.7.4. Health4Life evidence base

Health4Life has been evaluated via a cluster RCT in 71 schools across three states in Australia (New South Wales [NSW], Queensland [QLD] and Western Australia [WA]), with 6,639 students aged 11-14 years at baseline (Champion et al., 2023). The RCT included annual data collection assessments starting with baseline and post-intervention in 2019, followed by 12-month in 2020, 24-month in 2021 and the final 36-month data collection assessments in 2022 (Teesson et al., 2020). At each time point from post-intervention to 36-months, students completed four questionnaires assessing their engagement with the six lifestyle risk behaviours targeted in the intervention. After completing questionnaires, students received personalised feedback on their adherence to national health guidelines. Additionally, at post-intervention, students and teachers in the intervention group completed evaluation surveys, and teachers also completed a logbook survey to report on the fidelity and feasibility of *Health4Life*. The trial found no significant intervention effects on the primary outcomes, that is, on modifying the six lifestyle risk behaviours across the entire sample (Champion et al., 2023). Despite no behaviour change reported, knowledge related to the six lifestyle risk behaviours significantly improved at the 24-month follow-up and *Health4Life* was positively received by students (74.8%) and teachers (84%). Moreover, there were significant intervention effects at post-intervention for secondary outcomes including reducing students' intentions to try alcohol and tobacco (O'Dean et al., 2024), and psychological distress and depressive symptoms (Smout, Champion, O'Dean, Gardner, et al., 2024). Although important to note is that there were sociodemographic differences at baseline (Champion et al., 2021), with a greater prevalence of poor diet, alcohol and tobacco use among disadvantaged adolescents than among their more advantaged peers. With this in mind, investigating whether SES and geographical location influenced the efficacy of *Health4Life* is critical, as this may inform whether adapted versions of the program are needed to improve efficacy for these subgroups.

1.8. Summary of knowledge gaps

A summary of the knowledge gaps which this thesis aims to address in the preceding sections are printed in Table 1.

Table 1.1. Summary of knowledge gaps

1. Lack of recent Australian adolescent data on the prevalence of lifestyle risk behaviours among diverse sociodemographic groups.
• Most studies are outdated, and assess diet, alcohol, tobacco, and e-cigarette use separately across different adolescent samples, limiting understanding of their collective differences. • Alternatively, studies focus on younger adolescents (approximately 10-13 years), missing insights into behaviours such as alcohol and tobacco use that typically emerge in later adolescence. • Key factors such as gender and psychological distress, which influence these behaviours, are often unadjusted for in previous analyses. • Few recent studies examine how these behaviours collectively differ between disadvantaged (low SES and/or geographically remote [‘regional’]) and more advantaged adolescents in Australia.
2. Lack of evidence about the efficacy of eHealth interventions targeting lifestyle risk behaviours among disadvantaged adolescents (low SES and/or regional).
• While single studies and systematic reviews of eHealth interventions demonstrate their evidence of effectiveness for addressing poor diet, alcohol use, and tobacco smoking, most of this research has focused on the general population, with little evidence specific to disadvantaged adolescents. • Reviews on vaping interventions are particularly lacking, with their effectiveness among disadvantaged youth unclear. • To date, no systematic review has assessed the evidence supporting eHealth interventions in preventing poor diet, alcohol use, tobacco smoking, and vaping among disadvantaged adolescents (low SES and/or regional).
3. Lack of evidence regarding SES and geographical factors influence on the effectiveness of universal multiple health behaviour change (MHBC) digital-based interventions.
• Challenges exist in ensuring universal MHBC digital interventions reach and benefit disadvantaged adolescents as effectively as advantaged peers. • A meta-analysis found universal school-based MHBC interventions had limited effectiveness in reducing alcohol use, smoking, and certain poor diet behaviours (e.g., SSB, fat, and snack consumption).

- SES and geographical factors significantly influence health behaviours, but their role in the effectiveness of universal MHBC interventions remains unclear.

4. Lack of evidence regarding facilitators and barriers to disadvantaged adolescents' participation in digital school-based interventions.

- Understanding intervention implementation processes and associated contextual factors is key to ensuring they facilitate disadvantaged adolescents' participation.
- Few process evaluations of school-based digital interventions targeting lifestyle risk behaviours focus on disadvantaged adolescents, with even less using data from both students (end-user) and teachers (support intervention implementation).
- SES and geographic factors influence health behaviours, making it vital to assess their impact on implementation and outcomes to ensure school-based digital interventions meet disadvantaged adolescents' needs.

5. Lack of evidence about the acceptability of effective evidence-based digital interventions developed in Australia in other less advantaged contexts.

- Upper-middle-income countries such as Colombia lack standardised alcohol prevention in schools, despite early alcohol initiation.
- Adapting effective interventions from high-income countries such as Australia may potentially address this gap, given the high cost and resource demands of developing new programs in lower-resource settings.
- However, little evidence exists on the acceptability and feasibility of evidence- and school-based digital interventions targeting alcohol developed in Australia when applied in Colombia.

1.9. Thesis aims and outline

This thesis aims to address identified research knowledge gaps by creating and implementing studies and processes for the prevention of chronic disease risk behaviours among adolescents from low SES and geographically remote contexts. This research will provide evidence that can inform effective interventions, policy and practice among disadvantaged populations. Specifically, this thesis aims to:

1. Identify the prevalence and patterns of poor diet, alcohol use, tobacco smoking and vaping across different sociodemographic adolescent groups in Australia, with comparisons between adolescents classified as:

    a. disadvantaged (low SES and/or living regionally) and more advantaged (mid to high SES and/or living in metropolitan areas),
    b. across different SES levels (low, mid, and high),
    c. and geographical locations (regional compared to metropolitan adolescents).
2. Systematically review the efficacy of eHealth interventions targeting adolescents from disadvantaged contexts in preventing poor diet, alcohol use, tobacco smoking, and vaping.
3. Examine the influence of SES and geographical location on the efficacy of the universal school-based *Health4Life* intervention in reducing alcohol and tobacco use, improving dietary habits, knowledge of chronic disease risk behaviours, behavioural intentions and reducing psychological distress.
4. Investigate the implementation and relevance of the universal school-based *Health4Life* intervention among disadvantaged adolescents in Australia.
5. Assess the acceptability and potential global scalability of an effective eHealth school-based alcohol use prevention program, the *OurFutures Alcohol Module*, among disadvantaged adolescents overseas such as Bogotá, Colombia.

These five objectives are explored across five novel empirical chapters (Chapters 2-6 of this thesis), each summarised briefly below. The broader implications and recommendations derived from this research are discussed in detail in the final discussion chapter (Chapter 7).

Chapter 2 provided a key update to the current evidence base on lifestyle risk behaviours among distinct sociodemographic adolescent groups in Australia. Using cross-sectional data from 4,445 adolescents (M_{age}=15.7 years, SD=0.6; 47.0% female-identifying) across 71 schools in 2022, this study reported on the prevalence of adolescent dietary intake (sugar-sweetened beverages (SSBs); discretionary foods; fruit; and, vegetables), and past 6-month alcohol (standard drink; binge drinking), tobacco, and e-cigarette use. These risk behaviours were compared across varying levels of SES and geographical locations, and their intersections – adjusting for gender and psychological distress, which are often unadjusted for in other analyses.

Chapter 3[1] is the first study to systematically synthesise evidence for eHealth interventions targeting low SES and/or geographically remote ('regional', 'rural', and 'remote') adolescents in preventing poor diet, alcohol use, tobacco smoking and vaping. A systematic

review of the literature was conducted, with 15 publications assessing 14 interventions included, comprising 7170 youth (aged 9–18 years, 50.1% female, 56% low-mid SES, 33% remote).

Chapter 4[1] built on the findings of Chapter 3 by evaluating the influence of SES and geographical location, on *Health4Life*, a universal eHealth, school-based intervention targeting multiple lifestyle risk behaviours. Using data from the large, multi-site *Health4Life* cluster RCT (n=6,639, 71 Australian schools), this study examined behaviour change related to poor diet, alcohol use, tobacco smoking, behavioural intentions (diet-, alcohol-, and tobacco-related), psychological distress and knowledge. Latent growth models in Mplus were used to assess the moderating effects of SES and geographical location on between-group change over 24-months (2019-2022).

Chapter 5[1] provided further insights into differences reported in the outcomes of Chapter 4, alongside barriers and facilitators to participation in *Health4Life*, by conducting a process evaluation of *Health4Life* among a subsample of 214 disadvantaged students and their teachers (n=16). Quantitative data were analysed using descriptive statistics and open-ended responses were thematically analysed.

Chapter 6[1] marks an essential first step in informing the adaptation of an effective eHealth school-based alcohol prevention program originally developed in Australia, the *OurFutures Alcohol Module*, for use in an international context, specifically in Bogotá, Colombia. Following a mixed-methods case-study design, this study collected data in Spanish from three 1.5hr focus group sessions with adolescents, and ten 1hr interviews or online surveys with teachers. Qualitative data were analysed thematically, and descriptive analyses of quantitative data reported percentage agreement for survey questions.

[1] Chapters 3-6 have been peer-reviewed and published in national and international journals. These chapters are identical to the published journal articles, with the exception of the inclusion of a preface specifically written for this thesis.

Table 1.2. Summary of Thesis Overview

Gap	Aim	Chapter and title
1. Lack of recent Australian adolescent data on the prevalence of lifestyle risk behaviours among diverse sociodemographic groups.	1. Identify the prevalence and patterns of poor diet, alcohol use, tobacco smoking and vaping across different sociodemographic adolescent groups in Australia.	2. Who reports greater lifestyle risk behaviours? A closer look at sociodemographic differences among Australian adolescents: a cross-sectional analysis.
2. Lack of evidence about the efficacy of eHealth interventions targeting lifestyle risk behaviours among disadvantaged adolescents (low SES and/or geographically remote [‘regional’]).	2. Systematically review the efficacy of eHealth interventions targeting adolescents from disadvantaged contexts in preventing poor diet, alcohol use, tobacco smoking, and vaping.	3. eHealth Interventions targeting poor diet, alcohol use, tobacco smoking and vaping among disadvantaged adolescents: A systematic review.
	3. Examine the influence of SES and geographical location on the efficacy of the universal school-based *Health4Life* intervention in reducing alcohol and tobacco use, improving dietary habits, knowledge of chronic disease risk behaviours, behavioural intentions and reducing psychological distress.	4. Moderating effects of socioeconomic status and geographical location on the Health4Life school-based intervention.
3. Lack of evidence regarding facilitators and barriers to disadvantaged adolescents’ participation in digital school-based interventions.	4. Investigate the implementation and relevance of the universal school-based *Health4Life* intervention among disadvantaged adolescents in Australia.	5. Process evaluation of the digital Health4Life intervention among a sample of disadvantaged adolescents and teachers.
4. Lack of evidence about the acceptability of effective evidence-based digital interventions developed in Australia in other less advantaged contexts.	5. Assess the acceptability and potential global scalability of an effective eHealth school-based alcohol use prevention program, the *OurFutures Alcohol Module*, among disadvantaged adolescents overseas such as Bogotá, Colombia.	6. A mixed-methods study among adolescents and teachers in Bogotá, Colombia: Adapting the OurFutures Alcohol Program.

Chapter 2

Who reports greater lifestyle risk behaviours? A closer look at sociodemographic differences among Australian adolescents: a cross-sectional analysis

Preface

This chapter provides a key update to the current evidence base on lifestyle risk behaviours (dietary habits, alcohol use, tobacco smoking, and vaping) among distinct sociodemographic adolescent groups in Australia. **Chapter 1** identified that many existing studies on this topic are outdated, or narrow in scope by assessing diet, alcohol, tobacco, and vaping separately. Previous research has also focused on younger adolescents (aged 10-13 years), limiting understanding of lifestyle risk behaviours emerging during later adolescence. Additionally, many studies fail to account for important covariates, such as gender and psychological distress, which can influence these lifestyle risk behaviours. To address this gap, this chapter uses cross-sectional data from a large and diverse sociodemographic sample of Australian adolescents (M_{age}=15.7 years) in 2022, to report on the prevalence of lifestyle risk behaviours, adjusting for gender and psychological distress.

This chapter addresses the first aim of this thesis (Table 1.2):
Identify the prevalence and patterns of poor diet, alcohol use, tobacco smoking and vaping across different sociodemographic adolescent groups in Australia, with comparisons between adolescents classified as:

a. *'disadvantaged' (low SES and/or living regionally) and 'more advantaged' (mid to high SES and/or living in metropolitan areas),*
b. *across different SES levels (low, mid, and high),*
c. *and geographical locations (regional compared to metropolitan adolescents).*

This chapter is currently under review as:
Egan, L., O'Dean, S., Gardner, L. A., Newton, N. C., & Champion, K. E. Who reports greater lifestyle risk behaviours? A closer look at sociodemographic differences among Australian adolescents: a cross-sectional analysis. *Health Promotion Journal of Australia.*

2.1. Abstract

Issue addressed: Recent Australian adolescent data on the prevalence of lifestyle risk behaviours among diverse sociodemographic groups is lacking. This study examined the prevalence of dietary intake (sugar-sweetened beverages (SSBs); discretionary foods; fruit; vegetables), and alcohol (standard drink; binge drinking), tobacco, and e-cigarette use, across adolescents of diverse socioeconomic status (SES) and geographical locations.

Methods: Cross-sectional data were analysed from 4445 adolescents across 71 schools in 2022 (M_{age}=15.7 years, SD=0.6; 47.0% female-identifying). Fourteen percent (n=571) were categorised as low SES and 86% (n=3518) as mid-to-high SES, relative to the study sample, with nine percent (n=399) from regional areas. Binary logistic regressions compared differences for each outcome across SES and geographical locations, controlling for gender, psychological distress, intervention status and school clustering.

Results: Low SES adolescents had a lower prevalence of excessive discretionary food intake (PR=0.87, 95%CI=0.77-0.99), standard drink consumption (PR=0.78; 95%CI=0.65-0.93) and binge drinking (PR=0.68; 95%CI=0.50-0.92) compared to mid-to-high SES adolescents. Regional adolescents had a higher prevalence of standard drink consumption (PR=1.41; 95%CI=1.00-1.97), binge drinking (PR=1.77; 95%CI=1.07-2.93), and tobacco smoking (PR=2.06; 95%CI=1.18-3.60) compared to adolescents in major cities. Excessive discretionary food intake was less prevalent among adolescents from disadvantaged backgrounds (PR=0.84, 95%CI=0.76-0.94) compared to more advantaged adolescents.

Conclusion: Lifestyle risk behaviours among adolescents differ across SES and geographical locations, with regional adolescents fairing considerably worse across alcohol and tobacco use outcomes. Prevention for diet-related behaviours should be improved for more advantaged adolescents, while tailored interventions to SES and geographical location separately may be required for alcohol-, tobacco-, and e-cigarette use.

2.2. Background

Lifestyle risk behaviours including poor diet, alcohol use and tobacco smoking are well-known contributors to chronic diseases such as cancer, diabetes, and cardiovascular and lung

diseases (GBD 2021 Risk Factors Collaborators, 2024). In Australia, these are among the most prevalent chronic diseases and contribute significantly to the national burden of disease (Australian Bureau of Statistics, 2022b). Chronic diseases are in fact the leading cause of mortality in Australia (GBD 2019 Australia Collaborators, 2023) and accounted for 85% of total disease burden in 2023 (Australian Institute of Health and Welfare, 2024b). Compounding this issue, individuals living in lower socioeconomic areas and areas outside of major cities experience a greater prevalence of chronic conditions compared to their counterparts in higher socioeconomic areas and major cities, respectively (Australian Institute of Health and Welfare, 2024b). These health disparities – and restricted opportunities for cultivating healthy lifestyles – may in part be influenced by factors such as stigma (Robards et al., 2018), limited social support (WHO, 2016), restricted employment opportunities, and limited infrastructure and greater geographic spread impacting access to health care options (Australian Institute of Health and Welfare, 2024d). This sociodemographic gradient in health is persistent across varying life stages (e.g. early life disadvantage can influence health risk in adulthood (Yang et al., 2020) and health and educational challenges (Villadsen et al., 2023)). Thus, preventing known lifestyle risk behaviours is a key step towards reducing health inequities for lower socioeconomic status (SES) and/or 'regional' – 'rural', and 'remote' – populations (herein referred to as 'disadvantaged'). Recent research has also highlighted growing concerns regarding the health risks and harmful effects associated with e-cigarette use (vaping), with adolescents especially vulnerable (Banks et al., 2022; Cuomo et al., 2024). A study of 5114 Australian adolescents found that the risk of initiating tobacco smoking was almost five times higher for those who had ever used an e-cigarette compared to those who had not, with younger adolescents reporting a considerably greater risk (Egger et al., 2024). As many of these lifestyle risk behaviours emerge during adolescence, prevention efforts during this period that facilitate establishing healthy lifestyle habits protective against chronic disease are key for promoting long-term health outcomes (Mastorci et al., 2024; Patton et al., 2016; R. M. Viner et al., 2012). However, to ensure health-promoting education and prevention efforts benefit *all* adolescents, it is first important to understand any differential prevalence and patterns of lifestyle risk behaviours by varying sociodemographic groups.

Previous national data and studies suggest that disadvantaged adolescents are generally more likely to engage in lifestyle risk behaviours, such as not meeting national dietary guidelines and consuming unhealthy foods (Australian Institute of Health and Welfare, 2022; Boylan et

al., 2017), and reporting higher rates of risky alcohol consumption and tobacco smoking (Australian Institute of Health and Welfare, 2022; Chan et al., 2015; Coomber et al., 2011), compared to their more advantaged peers. International research demonstrates similar findings (Kim & Selya, 2022; Palakshappa et al., 2020; Shackleton et al., 2019). Vaping prevalence trends, however, appear to vary between Australia and other countries. In Australia, among people aged 14 and over, those with high SES report a higher likelihood of vaping (6.6%) compared to those of low SES (3.1%), (Australian Institute of Health and Welfare, 2024c) although other research has reported no difference by SES in vaping prevalence among Australian adolescents (Gardner, O'Dean, et al., 2023). International studies however (e.g. United Kingdom, United States, and Germany) have reported a greater prevalence of vaping among adolescents of lower SES and/or from regional areas compared to their counterparts (Dai et al., 2021; Green et al., 2020; Hanewinkel & Hansen, 2024). Nevertheless, much of this evidence provides a snapshot of these diet-related, alcohol, tobacco and e-cigarette use risk behaviours assessed separately from each other across different study samples. Additionally, limited recent research has explored how these behaviours collectively differ between disadvantaged (low SES and/or regional-based) and more advantaged adolescents in Australia. Although Champion et al. (2021) and Gardner, O'Dean, et al. (2023) examined these behaviours in the same Health4Life Study sample and found no sociodemographic differences, neither study assessed these behaviours collectively across disadvantaged groups (i.e., combining low SES and/or regional for comparison to more advantaged adolescents), nor did not they adjust for gender and psychological distress which can be associated with these behaviours (Shawon et al., 2023; Slade et al., 2024; Smout, Champion, O'Dean, Halladay, et al., 2024). Additionally, Champion et al. (2021) analysis focused on 11-14-year-olds thus before typical initiation ages for alcohol and tobacco use among Australian adolescents (Gardner, Stockings, et al., 2024; Guerin & White, 2018).

The current study addresses shortcomings in the existing literature by using data from a large, geographically diverse, Australian cluster randomised controlled trial (RCT) to better understand differences in lifestyle risk behaviours across distinct sociodemographic adolescent groups in Australia, while controlling for gender and psychological distress. Specifically, this study aims to:

(1) examine the prevalence of poor dietary intake (excessive sugar-sweetened beverages (SSBs) and discretionary foods, and insufficient fruit and vegetables), alcohol use, tobacco smoking, and vaping among adolescents of low SES versus mid-to-high SES, and between regional and metropolitan adolescents and;

(2) compare the prevalence of these behaviours among disadvantaged (low SES and/or living regionally) versus more advantaged (mid-to-high SES and/or living in metropolitan areas) adolescents.

2.3. Methods

The methods for this study have been written per the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies (von Elm et al., 2007).

2.3.1. Data source

The current study uses 36-month follow-up data from the *Health4Life* Study collected between 1 July–31 December 2022. The full study methodology, recruitment and consent procedures for *Health4Life* are reported elsewhere (Champion et al., 2023; Teesson et al., 2020). Briefly, *Health4Life* is a large cluster RCT that commenced in 2019 and involved 6639 Year 7 (baseline age 11-14 years) students from 71 secondary schools across three states in Australia (New South Wales [NSW], Queensland [QLD] and Western Australia [WA]). Self-report online surveys completed during class were used to collect data over the study period, with a total of 4445 participants (67%) having completed the 36-month follow-up survey, constituting the sample for this study. Ethical approvals for the study were received by the University of Sydney (2018/882), the University of Queensland (2019000037), Curtin University (HRE2019–0083), and relevant school sector ethics committees.

2.3.2. Measures

2.3.2.1. Demographic characteristics

SES, geographical location, gender identity and symptoms of psychological distress were self-reported by students. Participants' SES was measured using the Family Affluence III (FASIII) scale at baseline, with FASIII scores transformed into ridit scores to categorise

participants into lower, middle and upper SES groups relative to the study population (Elgar et al., 2017). Thus, participants were considered as relatively low, mid, or high SES. Participants' school location was used as a proxy for their geographical location as many students were unsure of their home postcode. Geographical location of schools were measured using the Australian Statistical Geography Standard Remoteness Structure (Australian Bureau of Statistics, 2023), which classifies geographical areas as major city, inner regional, outer regional, remote, or very remote, with remoteness increasing as distance from services increases. Gender identity was measured using an ACON-recommended gender-related indicator research question that asked participants to describe their gender including responses for 'male', 'female', 'non-binary', 'other identity' or 'prefer not to answer' (ACON, n.d.).

2.3.2.2. Psychological distress

The presence of psychological distress symptoms were measured using the Kessler six-item scale (K6) which has been validated among adolescents and measures the frequency of symptoms such as feeling nervous, hopeless, restless, worthless in the previous month (Furukawa et al., 2003; Mewton et al., 2016). Participants responded to questions on a 5-point Likert scale with answers scored from "none of the time" to "all of the time". Higher K6 scores indicated greater psychological distress. K6 scores were dichotomised based on published cut-points for serious mental illness (SMI), where scores above 13 indicated a SMI (=1 Yes) and those below 13 suggested no SMI (=0 No) (Peiper et al., 2015).

2.3.2.3. Lifestyle risk behaviours

Diet: Students self-reported their consumption of SSBs, fruit, vegetables, and discretionary foods in response to questions from the Student Physical Activity and Nutrition Survey (SPANS) (Hardy et al., 2016). To assess SSB consumption, participants were asked about how many cups of water, fruit juice, diet soft drinks (e.g. Diet Coke) and soft drinks (e.g. Coke), cordials or sports drinks they usually consumed. A figure showing different sizes of these drinks was shown to facilitate student responses (see Appendices pg. 2). Responses were then dichotomised to categorise SSB consumption with 5+ cups/week coded as excessive (=1) and less than 5 cups as not (=0). For fruit and vegetables, participants were asked how many servings of fruit and vegetables they usually eat each day. A pictorial chart showing serving sizes of fruit and vegetables was shown to assist participant responses (see

Appendix 1.1). Fruit and vegetable variables were separately dichotomised to indicate <2 servings of fruit/day or <5 servings of vegetables/day as insufficient fruit or vegetable intake (=1) and 2+ servings of fruit/day or 5+ servings of vegetables/day as sufficient (=0), in line with the Australian National Dietary Guidelines (National Health and Medical Research Council, 2013). For discretionary food consumption, participants reported how often they usually consumed junk foods such as hot chips, snack foods such as cakes, confectionary items (e.g. chocolate), ice cream, and takeaway meals from fast food outlets such as McDonald's (see Appendix 1.1). This variable was dichotomised, where consuming discretionary food items once or more per day was coded as excessive (=1) and responses less than this as not excessive (=0).

Alcohol: A single-item assessed participants' consumption of a full standard drink in the last 6 months, "Have you had a full standard alcoholic drink in the past 6 months?" (0=No, 1=Yes). Binge-drinking in the previous 6 months was assessed via "How often did you have 5 or more standard alcoholic drinks on one occasion in the past 6 months". Participants answering 'never' were categorised as did not binge drink (=0), and any responding between 'less than monthly' to 'daily or almost daily' were categorised as did binge drink in the previous 6 months (=1). A visual aid showing standard drink sizes of various alcoholic beverages according to the Australian Drinking Guidelines was shown alongside alcohol-related questions to facilitate participants' responses (see Appendix 1.1).

Tobacco: Previous 6-month tobacco use was captured using a single item measure from the Youth Risk Behaviour Survey, with participants asked, "In the past 6 months, have you tried cigarette smoking, even one or two puffs?" (0=No, 1=Yes) (Brener et al., 2013).

Vaping: Previous 6-month vape use was assessed using two items. First, participants were asked, "Have you ever used an e-cigarette, even one or two puffs?". Participants who responded "Yes" were then asked, "When did you last use e-cigarettes?". Responses ranging between, "In the past day (24-hours)" to "More than 3-months ago, but within the past 6-months" were categorised as "Yes=1". Responses ranging from "More than 6 months ago, but within the past 12-months" to "More than 12-months ago" were categorised as "No=0", as were those who answered "No" to having ever used an e-cigarette.

2.3.3. Statistical Analysis

Descriptive statistics summarised sample characteristics and prevalence estimates of each lifestyle risk behaviour across three groupings. Group 1 compared adolescents of low SES to mid-to-high SES. Group 2 compared adolescents in regional areas to those in major cities. Group 3 compared disadvantaged adolescents (i.e. low SES and/or living regionally) to more advantaged adolescents (i.e. mid or high SES and/or living in major cities). Binary logistic regression models using the *prLogistic* package in R calculated prevalence ratios (PRs) for each outcome following the conditional standardisation procedure, with 95% confidence intervals (CIs) estimated using the delta method (Amorim & Ospina, 2021). Three separate models were run per outcome. The first model compared mid-to-high SES to low SES, adjusting for gender identity, psychological distress, intervention status, school-level clustering and geographical location. The second model focused on geographical location (major city versus regional), with gender identity, psychological distress, intervention status, school-level clustering and SES (mid-to-high SES versus low SES) as covariates. The third model compared disadvantaged (i.e. low SES and/or living regionally) to more advantaged participants (i.e. mid or high SES and/or living in major cities), adjusting only for gender identity, psychological distress, intervention status and school-level clustering. A significant difference in prevalence was reported if the 95% CI did not cross 1. Complete case analysis was used for each model, the missing data for each outcome was <10% (i.e. very low) and the sample size was considerable, therefore no additional analysis of missing data was done (Jakobsen et al., 2017). The only exception was that 18% of regional adolescents' responses to the discretionary food consumption measure were missing, however, results from a simple regression analysis indicated missing responses were not related to greater discretionary food consumption risk at baseline. Further details of the simple regression analysis are reported in Appendix 1.8. Data analysis was done using R version 4.3.3.

2.4. Results

Among the 4445 participants (M_{age}=15.7 years, SD=0.6; 47.0% female-identifying), 54% (n=2398) were located in NSW, 27.3% (n=1212) in QLD and 18.8% (n=835) in WA, with 91% attending schools in major city areas (remaining 9% in regional areas). Fourteen percent (n=571) of participants were classified as low SES and 86% (n=3518) as mid-to-high SES relative to the study sample. Further details of the sample characteristics are reported in Table 2.1 (see Appendix 1.4 and Appendix 1.6 for sample characteristics grouped by relative SES

and geographical location, respectively). The overall prevalence of risk behaviours among the study sample are included in Figure 2.1.

2.4.1. Model 1: SES (low SES versus mid-to-high SES) comparison

Compared to participants from mid-to-high SES backgrounds, excessive discretionary food consumption was 13% less prevalent among low SES participants (PR=0.87; 95% CI=0.77-0.99). Low SES participants also reported a 22% lower prevalence of consuming a full standard drink (PR=0.78; 95% CI=0.65-0.93) and 32% lower prevalence of binge drinking (PR=0.68; 95% CI=0.50-0.92) in the previous 6-months (see Appendix 1.5 and Appendix 1.8).

2.4.2. Model 2: Geographical location (regional versus major city) comparison

Compared to participants from major cities, the participants from regional areas reported a 41% higher prevalence of consuming a full standard drink (PR=1.41; 95% CI=1.00-1.97), 77% higher prevalence of binge drinking (PR=1.77; 95% CI=1.07-2.93), and 106% higher prevalence of tobacco smoking (PR=2.06; 95% CI=1.18-3.60) in the previous 6-months (see Appendix 1.7 and Appendix 1.8).

2.4.3. Model 3: Disadvantaged (low SES and/or regionally located) compared to more advantaged (mid-to-high SES and/or major city)

After adjusting for gender, psychological distress, intervention status, and school clustering, only excessive discretionary food consumption (PR=0.84; 95% CI=0.76-0.94) was significantly less prevalent (16%) among disadvantaged compared to more advantaged adolescents (see Appendix 1.3 and Appendix 1.8).

Table 2.1. Selected sample characteristics of participants (N= 4445)

	Whole sample (N = 4445)	**Disadvantaged sub-sample** (N = 896)	**More advantaged sub-sample** (N = 3549)
Age (mean [SD])	15.71 (0.64)	15.71 (0.66)	15.69 (0.53)
Gender identity (N [%])			
Male	2172 (49.0%)	516 (57.7%)	1656 (46.8%)
Female	2065 (46.6%)	336 (37.6%)	1729 (48.9%)
Non-binary	123 (2.8%)	25 (2.8%)	98 (2.8%)
Prefer not to say	73 (1.7%)	17 (1.9%)	56 (1.6%)
Psychological distress (N [%])			
No	3349 (79.9%)	674 (81.0%)	2675 (79.6%)
Yes	844 (20.1%)	158 (19.0%)	686 (20.4%)
State (N [%])			
NSW	2398 (54.0%)	520 (58.0%)	1878 (52.9%)
QLD	1212 (27.3%)	127 (14.2%)	1085 (30.6%)
WA	835 (18.8%)	249 (27.8%)	586 (16.5%)
Socio-economic status (N [%])			
Low	571 (14%)	571 (66.9%)	0 (0%)
Mid-to-High	3518 (86.0%)	283 (33.1%)	3235 (100%)
Geographical location (N [%])			
Major city	4046 (91%)	497 (55.5%)	3549 (100%)
Regional	399 (9%)	399 (44.5%)	0 (0%)

Figure 2.1. Prevalence of risk behaviours among 4445 participants aged 14–17 years in the Health4Life trial at 36-month post-baseline follow-up, and prevalence ratios (with 95% confidence intervals), by socio-demographic characteristics*

The forest plots per outcome represent three separate models, all of which adjust for gender, psychological distress, intervention status and school clustering. Model 1 compared mid-to-high SES versus low SES, additionally adjusting for geographical location. Model 2 compared major city versus regional, also adjusting for SES. Model 3 compared more advantaged (mid-to-high SES and/or major city) versus disadvantaged (low SES and/or regional). Reference groups are denoted in brackets. *The data for this figure are in Appendix 1.8.

2.5. Discussion

This cross-sectional study investigated differences in the prevalence of eight lifestyle risk behaviours by sociodemographic and geographical location in a large sample of Australian adolescents aged 14–17 years. We found that adolescents of lower SES compared to those classified as mid-to-high SES, reported a lower prevalence of excessive discretionary food intake (13%), consuming a full standard alcoholic drink (22%), and binge drinking (32%). Contrastingly, geographical location differences did not follow this trend. Regional participants reported a higher prevalence of consuming a full standard drink (41%) and binge drinking (77%) than participants in major cities. Alarmingly, tobacco use was more than twice as prevalent (106%) among regional participants. When comparing disadvantaged adolescents (low SES and/or regional) to more advantaged (mid-to-high SES and/or major city) adolescents, only discretionary food intake was significantly lower (16%) among disadvantaged adolescents.

Our findings that excessive discretionary food consumption was lower among disadvantaged adolescents compared to more advantaged adolescents, and among adolescents of lower SES compared to those of mid-to-high SES, suggests low SES may uniquely protect against excessive discretionary food consumption. This contrasts with previous Australian research showing greater fast-food consumption among low SES adolescents than their more advantaged peers (Niven et al., 2014; Scully et al., 2020), and among those in metropolitan areas compared to regional areas (Scully et al., 2020). It may be that social (e.g. cultural-related food practices), environmental (e.g. local food banks) and economic (e.g. cost of fast-food proportionate to income) factors potentially prevent low SES adolescents from consuming excessive discretionary foods. Low-income households generally spend less on meals out and fast food than high-income households (Australian Bureau of Statistics, 2015-16), reducing opportunities to eat discretionary foods. This is potentially related to the high and rising costs of goods in Australia including take-away foods, which can take up a large proportion of their disposable income (Black et al., 2024; Lee et al., 2016). Moreover, disadvantaged populations are more likely to rely on food assistance programs which tend to provide healthier food items (Reeve et al., 2020). This highlights the importance of public health efforts addressing environmental and economic factors influencing dietary choices, and the need for targeted strategies to support more advantaged adolescents reduce their intake of discretionary foods.

The alcohol-related outcomes demonstrate an interesting contrast. While consuming a full standard drink and binge drinking was less prevalent among adolescents of lower SES compared to mid-to-high SES, the opposite was seen for regional adolescents who had a higher prevalence of these outcomes than adolescents in major cities. This suggests alcohol patterns are uniquely different between low SES and regional adolescents. These findings align with recent wastewater analysis from various metropolitan, regional and socioeconomic areas across Australia showing greater alcohol consumption in higher compared to lower socioeconomic areas, and select regional areas compared to major cities (Tscharke et al., 2024). For those classified as lower SES adolescents in our study, the cost of alcohol may have been a barrier, or social, cultural and familial factors could have played a role, particularly if they identified as culturally and linguistically diverse which can be protective against alcohol consumption (Douglass et al., 2024; Rowe et al., 2020). On the other hand, regional adolescents may have been more likely to obtain alcohol from parents and experience less parental disapproval towards alcohol use compared to their peers in major cities, thus encouraging higher alcohol consumption (Chan et al., 2016; Chan et al., 2015).

Aligning with previous literature, tobacco smoking was more prevalent among regional adolescents versus those based in major cities (Coomber et al., 2011). This is especially concerning, as tobacco smoking is not only associated with immediate health consequences (e.g. shortness of breath) and heightened risk for chronic disease, but regional adolescents who have tried cigarettes at least once may be more likely than their counterparts to become a daily smoker (Lutfiyya et al., 2008). Considering the high potential for tobacco dependence after as few as four tobacco cigarettes and the challenges of quitting without support–even when there is a desire to–this further adds to regional adolescents' vulnerability to chronic disease burden as they have less access to smoking cessation and other treatment services (Ramsey et al., 2020; Tall et al., 2015; WHO, 2023c). This disparity in smoking prevalence may stem from greater exposure to friends or parents who smoke which are known risk factors (Altwicker-Hámori et al., 2024; Scully, Greenhalgh, et al., 2023), particularly as regional households with children tend to have a greater proportion of smokers compared to major city households (Longman & Passey, 2013). Furthermore, regional adolescents may be exposed to greater pro-tobacco advertising (Pesko & Robarts, 2017), potentially creating an environment where tobacco smoking is more socially accepted than in major cities.

In terms of vaping, although there were no significant differences across all comparisons in our study, we typically saw a lower prevalence of vaping among lower SES adolescents compared to mid-to-high SES adolescents, and higher prevalence in regional compared to major city-based adolescents, consistent with previous Australian data (Australian Institute of Health and Welfare, 2024c; Egger et al., 2024). This may reflect greater affluence among 79.3% of regional adolescents (categorised as mid-to-high SES relative to study sample; see Appendix Table 4) making e-cigarettes more affordable, or higher e-cigarette shop outlet density in regional areas. Indeed, some studies have found higher outlet density of stores selling e-cigarettes near secondary schools in regional Australia which is a risk factor for vaping (Tuson et al., 2024). Other risk factors include tobacco use, family or friends tobacco use, low-risk perception of vaping, and exposure to advertisements about e-cigarettes or tobacco cigarettes (Kim et al., 2022). These factors may have been more overt among regional adolescents, particularly as we saw a higher prevalence of tobacco smoking among regional adolescents than in major cities. Protective factors however include perceived cost and dangers of vaping, parental monitoring, not knowing or seeing someone who used e-cigarettes (Kim et al., 2022). For low SES adolescents, some of these factors such as cost of e-cigarettes coupled with less exposure to vaping advertisements (Simon et al., 2018) may have contributed to the lower vaping prevalence than mid-to-high SES peers.

Our findings point to the nuanced differences in the prevalence of these lifestyle risk behaviours across SES and geographical location. They suggest that, targeted strategies may be required to target diet behaviours among more affluent adolescents. In contrast, alcohol, tobacco smoking, and vaping behaviours may require tailoring to SES and geographical location separately. Public health policy and interventions must appropriately address the needs of diverse sociodemographic adolescent populations, with particular focus on disadvantaged adolescents who are vulnerable to experiencing health inequity (Australian Institute of Health and Welfare, 2024b). These prevention efforts should adopt a holistic approach integrating early intervention, health promotion (e.g. accessible health information), and policy change (e.g. stronger partnerships with low SES and regional communities to implement tailored evidence-based prevention programs). Ensuring equitable coverage is essential, digital interventions targeting these behaviours can be effective (Egan et al., 2023) and should be considered for large-scale prevention, particularly for low SES and regional adolescents as they have promise in reaching broad and diverse populations with less access barriers.

2.5.1. Strengths & Limitations

The current study has limitations warranting consideration. Given the cross-sectional design, the findings do not reflect any causal relationships between varying adolescent sociodemographic groups and lifestyle risk behaviours evaluated in this study. The use of self-reported measures are prone to bias as participants may have under- or over-reported aligning with social desirability of responses, although objective measures were not feasible considering the size of this RCT. The study sample were predominantly from major cities and of relative mid-to-high SES, indicating many disadvantaged adolescents were not included. For instance, in 2022, 64% of all students attended government schools, 20% attended Catholic and 16% attended independent schools, with 60% in major cities and 40% outside of major cities (Australian Bureau of Statistics, 2022d). Although the sample was still diverse including students from varying contexts including students from NSW, WA and QLD across independent, catholic and government schools, with >4000 students completing the survey. Thus, further research examining the current prevalence of these behaviours and a more representative sample is needed.

2.5.2. Conclusion

The current study has filled a gap in the literature regarding the prevalence of poor diet (insufficient fruit and vegetables, and excessive SSBs and discretionary food consumption), alcohol use (consumption of full standard drink and binge drinking), tobacco use and vaping by diverse sociodemographic adolescent groups in Australia. Adolescents of lower SES reported less alcohol consumption, binge drinking, and excessive food consumption compared to adolescents of mid-to-high SES, potentially influenced by social, cultural and economic factors including cost of alcohol and discretionary foods. Contrastingly, adolescents in regional areas compared to major cities had higher prevalences of alcohol consumption, binge drinking, and tobacco smoking suggesting current prevention approaches are not adequately reaching regional adolescents. Tracking these behaviours over time and examining representative samples to gain accurate prevalence estimates is crucial for informing prevention efforts to target these behaviours prior to them solidifying in the adolescents' behavioural repertoire. To safeguard the future health of *all* adolescents, prevention efforts should adopt a holistic approach integrating early intervention, health promotion, and policy change tailored proportionately to the needs of diverse adolescent groups. Increased investment in large-scale prevention is needed, and digital interventions are

one potentially feasible approach for reaching and targeting these lifestyle risk behaviours among diverse sociodemographic adolescent groups.

Chapter 3

eHealth Interventions targeting poor diet, alcohol use, tobacco smoking and vaping among disadvantaged adolescents: A systematic review

Preface

There is a significant lack of evidence regarding the effectiveness of eHealth interventions targeting lifestyle risk behaviours among disadvantaged adolescents, including those from low SES and/or geographically remote ('regional', 'rural', and 'remote') areas. While previous studies and systematic reviews have demonstrated the effectiveness of eHealth interventions in addressing poor diet, alcohol use, and tobacco smoking, most of this research has focused on the general adolescent population, and limited attention has been given to disadvantaged groups. Additionally, there is a notable lack of research on vaping interventions, and their effectiveness for disadvantaged adolescents is unclear. This chapter reports the first systematic review to evaluate eHealth interventions for preventing poor diet, alcohol use, tobacco smoking, and vaping among disadvantaged adolescents.

This chapter addresses the second aim of this thesis (Table 1.2):
Systematically review the efficacy of eHealth interventions targeting adolescents from disadvantaged contexts in preventing poor diet, alcohol use, tobacco smoking, and vaping.

This systematic review is available in Appendix A and has been published as:
Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E. (2023). A Systematic Review of eHealth Interventions Among Adolescents of Low Socioeconomic and Geographically Remote Backgrounds in Preventing Poor Diet, Alcohol Use, Tobacco Smoking and Vaping. *Adolescent Research Review*. 9:1-32. https://doi.org/10.1007/s40894-023-00210-2

The accompanying protocol is available in Appendix B and has been published as:
Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E. (2022). eHealth Interventions Targeting Poor Diet, Alcohol Use, Tobacco Smoking, and Vaping Among Disadvantaged Youth: Protocol for a Systematic Review. *JMIR Research Protocols*. 11(5):e35408. https://doi.org/10.2196/35408

3.1. Abstract

Disadvantaged adolescents such as those of low socioeconomic and geographically remote backgrounds experience disproportionate chronic disease burden and tend to engage in greater risk behaviours including poor diet, alcohol use, tobacco smoking, and vaping. The social, structural, and economical barriers to health that uniquely affect adolescents of low socioeconomic and geographically remote backgrounds, such as stigma, access to and affordability of services, may partially explain their disadvantage in attaining health equity. Universal eHealth interventions can provide effective prevention, however, it is unclear whether they benefit disadvantaged adolescents, including those from low socioeconomic and geographically remote contexts. This study systematically reviewed the effectiveness of eHealth interventions targeting disadvantaged adolescents in preventing poor diet, alcohol use, tobacco smoking and vaping. Of 3278 identified records, 15 publications assessing 14 interventions were included, comprising 7170 youth (aged 9–18 years, 50.1% female, 56% low-mid SES, 33% remote). Nine interventions targeted poor diet, three targeted alcohol, one targeted tobacco, and one targeted alcohol and tobacco. No interventions targeted vaping. eHealth interventions significantly increased fruit and vegetable intake and percentage energy of nutrient-rich food, decreased sugar-sweetened beverage consumption, total energy intake, nutrient-poor food percentage energy consumption, and were associated with reduced binge drinking at 1-month follow-up among intervention completers. The findings of this study highlight that eHealth interventions can be effective in targeting poor diet and alcohol use among disadvantaged adolescents. However, due to the limited number of studies meeting inclusion criteria for this study, it is critical future research focus on developing and evaluating effective eHealth interventions targeting disadvantaged adolescents.

3.2. Background

Disadvantaged adolescent populations, including those from low socioeconomic and geographical remote contexts, experience exponentially greater chronic disease burden than their counterparts and report higher rates of engagement in modifiable risk behaviours such as poor diet, alcohol use, tobacco smoking and vaping (Australian Institute of Health and Welfare, 2019a). Chronic diseases detrimentally affect an individual's health and wellbeing, and are associated with significant social and economic costs; this effect is exacerbated with multimorbidity (Australian Institute of Health and Welfare, 2020c). There is an opportunity

to alleviate disadvantaged adolescents' vulnerability to experiencing chronic disease burden across their lifetime in a cost-effective way by focusing on the prevention of key lifestyle risk behaviours prior to their establishment in adulthood (Solar & Irwin, 2010). There is growing evidence to support the use of electronic health (eHealth) interventions in delaying or preventing the onset of modifiable lifestyle risk behaviours among the general population (Newton et al., 2022; Qiu et al., 2022), however, their effect on disadvantaged adolescents has not yet been synthesised. Therefore, the purpose of this study is to systematically synthesise the literature on eHealth interventions among disadvantaged adolescents in preventing poor diet, alcohol use, tobacco smoking and vaping.

3.2.1. Disadvantage & Modifiable Lifestyle Risk Behaviours

Socioeconomic status refers to an individual's or group's social and economic position in relation to others in society (described as low, middle, and high), that affects access to resources and health outcomes (Australian Bureau of Statistics, 2011). In a country like Australia that covers 7 692 024 km^2, there are large geographic differences in where people live with long distances between major cities and regional, rural, and remote areas. As remoteness increases, accessibility to services and health outcomes decrease. For instance, according to 2018 figures populations living in remote and very remote areas experience 1.4 times greater burden of disease than those living in major cities (Australian Institute of Health and Welfare, 2024d).

Although low socioeconomic status and geographic remote backgrounds represent unique contexts, they share similar disadvantages to achieving health equity. It is for this reason the term 'disadvantaged' is used to describe low socioeconomic and geographically remote in this study. Disadvantaged adolescent populations face a multitude of social, structural, and economical barriers to health, such as stigma (Robards et al., 2018), less social support (WHO, 2016), access to and affordability of services, employment prospects and educational opportunities (Australian Institute of Health and Welfare, 2024d); and these may partly explain health inequity between population groups.

Importantly, lifestyle risk behaviours, such as poor diet, alcohol use, and tobacco smoking, are modifiable (GBD 2019 Diseases and Injuries Collaborators, 2020). Preventing the uptake or reducing engagement in these behaviours can lessen global disease, illness, and morbidity.

However, engagement with these behaviours differs across socioeconomic positions and between geographical areas; generally, more disadvantaged populations are faring worse. Australian children and adolescents living in the lowest socioeconomic area compared to the highest socioeconomic area report: lower fruit intake, higher consumption of sugar-sweetened beverages (SSBs), and an increased likelihood of risky alcohol consumption and smoking (Australian Institute of Health and Welfare, 2020a). Similar trends have been reported among disadvantaged adolescents overseas (Palakshappa et al., 2020; Shackleton et al., 2019). Vaping (electronic cigarette or "e-cigarette" use), however, emerged relatively recently, and is becoming increasingly more common among adolescents across the world (Tarasenko et al., 2021), despite growing evidence of the harmful health effects (Banks et al., 2022). The UK Household Longitudinal Study reported greater e-cigarette use among socioeconomically disadvantaged youth, particularly among never-smokers (Green et al., 2020), and the 2018–2019 Kansas Communities That Care Student Survey reported a higher prevalence of current e-cigarette use among adolescents from rural areas compared to urban areas (Dai et al., 2021).

3.2.2. Adolescence as a Key Stage for Prevention

Prevention interventions targeted at adolescents provide a unique opportunity to prevent key lifestyle risk behaviours as they are ideally delivered prior to the onset and entrenchment of such behaviours. This is on account of adolescence marking a critical period of growth and development where patterns for current and future life behaviours start to take form, often accompanied by increased risk-taking behaviour that can positively (e.g. competitive team sport) or negatively (e.g. substance use) influence health (Duell & Steinberg, 2019). The initiation of vaping, alcohol and tobacco use typically increases during adolescence (Degenhardt et al., 2016; Hammond et al., 2019), and dietary habits characteristically include greater consumption of nutrient-poor food (Murakami & Livingstone, 2016) including junk food (Australian Institute of Health and Welfare, 2018) and SSBs (Australian Institute of Health and Welfare, 2019b). These behaviours commonly cluster together (Gardner, Champion, et al., 2022) and have been regarded as "consumption behaviours" (Thornton et al., 2022), suggesting that consuming food, alcohol, or tobacco requires active participation. Short-term consequences associated with these behaviours include obesity (Bleich & Vercammen, 2018), diminished quality of life (Hoare, Crooks, et al., 2019; Hoare, Marx, et al., 2019), and behavioural and mental health problems (Hoare, Crooks, et al., 2019; Hoare,

Marx, et al., 2019). Many of these behaviours may persist into adulthood (Degenhardt et al., 2008), increasing chronic disease risk, particularly when they co-occur (Ding et al., 2015). Preventing these behaviours in adolescence is critical for safeguarding future health outcomes of disadvantaged populations, and engaging in health-promoting behaviours in adolescence shows promise in improving adolescent and adult health outcomes (Liu et al., 2012).

3.2.3. Viability of eHealth Interventions and Existing Systematic Reviews

Pertinent to the design of prevention interventions is consideration of the unique barriers experienced by disadvantaged adolescent populations. Electronic health (eHealth) interventions (e.g., computer-, web-, mobile-, or telephone-based) may be a viable option as they can be accessed remotely, at little cost to the end-user, and provide increased implementation fidelity and student engagement (Newton et al., 2017). As adolescents are high users of technology (Patton et al., 2016), eHealth provides an opportunity to connect with disadvantaged adolescents who may otherwise miss out on receiving interventions due to the aforementioned barriers. Several systematic reviews of eHealth interventions targeting poor diet, alcohol use, and/or tobacco smoking among adolescents have reported their effectiveness in: improving dietary behaviours (e.g. less unhealthy food and total fat and saturated fat consumption, and increased daily fruit and vegetable intake) (Kemp et al., 2021); reducing alcohol use (A. Hutton et al., 2020; Kazemi et al., 2021); and reducing the number of cigarettes and smoking frequency (Taylor et al., 2017). These reviews, however, focused on adolescents in the general population, and reviews on vaping are lacking. To date, no existing systematic review has focused specifically on eHealth interventions among adolescents living in geographically remote areas and/or of lower socioeconomic contexts targeting poor diet, alcohol use, tobacco smoking and vaping.

3.3. The Current Study

Due to the disproportionate chronic disease burden experienced by disadvantaged adolescents, innovative, effective and accessible prevention approaches are needed. Universal eHealth interventions among adolescents can provide effective prevention, therefore may be a practical option for preventing lifestyle risk behaviours such as poor diet, alcohol use, tobacco smoking and vaping among disadvantaged adolescents. However, the research on the effect of eHealth interventions among disadvantaged adolescents has yet to be systematically synthesised. This study aimed to address gaps in the literature by systematically reviewing

the evidence on the effectiveness of eHealth interventions targeting adolescents (aged 10–19 years) from disadvantaged backgrounds in preventing poor diet, alcohol use, tobacco smoking, and vaping. It was hypothesised that eHealth interventions targeting these risk behaviours among disadvantaged adolescents would be limited in number and effect, especially those targeting vaping due to its relatively recent emergence among adolescents and the paucity of research focused on vaping.

3.4. Methods

This systematic review was prospectively registered with PROPSERO (CRD42021294119) and was written as outlined in the published review protocol (Egan et al., 2022) and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols guidelines (Moher et al., 2015).

3.4.1. Search Strategy & Selection Criteria

A systematic search of seven electronic databases (Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, PROSPERO, MEDLINE [Ovid], Embase [Ovid], Scopus, and PsycInfo [Ovid]) was conducted December 19, 2022. An example search for MEDLINE [Ovid] is provided in Appendix 2.1. The search strategy was developed in consultation with a research librarian, and search terms were guided by the population, interventions, comparators, and outcomes (PICO) approach (Shamseer et al., 2015). Eligible studies were those that evaluated an eHealth intervention targeting poor diet, alcohol use, tobacco smoking, or vaping among adolescents aged 10–19 years (in line with the World Health Organisation's definition for "adolescents" (WHO, 2021a) of low socioeconomic or from geographically remote backgrounds. The comparator groups included participants in a control group (e.g. no intervention) or assessed outcomes based on changes over time. Randomised controlled trials and quasi-experimental studies, with no language or publish date restrictions were included. Studies were excluded if there was no clear eHealth intervention component or if interventions were targeted at the general population without specific sub-group analysis among disadvantaged adolescents.

3.4.2. Data Extraction

All identified articles were imported into EndNote software (Clarivate) for removal of duplicates, and subsequently uploaded to Covidence software (Covidence) for screening. The

reference lists of eligible studies were also searched to identify additional studies. Study titles and abstracts were independently reviewed by one author, and a subset (25%) of articles were double screened by the remaining study authors. Any disagreements were resolved through consultation. Data were extracted by one author using a standardised extraction form guided by the Template for Intervention Description and Replication checklist (Hoffmann et al., 2014), and reviewed by a second author.

3.4.3. Data Analysis

The primary outcome of interest was the prevention or reduction of alcohol (any consumption, total weekly-monthly alcohol consumption, heavy drinking, and frequency of binge drinking), tobacco (current vs non-smoker), and e-cigarette use, and improvements in dietary behaviours, including intake of fruit and vegetable, SSBs and nutrient-poor foods (junk food). Secondary outcomes included knowledge, intentions, and other health behaviours including physical activity, sleep and recreational screen time. Two authors independently assessed the risk of bias of included studies using the Cochrane Revised Risk of Bias Tool (Sterne et al., 2019). Any discrepancies between assessors were resolved through consultation. Study findings were summarised qualitatively following the UK Economic and Social Research Council guidance for narrative synthesis in systematic reviews (Popay et al., 2006).

3.5. Results

An overview of the study selection process is shown in a PRISMA flow diagram (Figure 3.1). A total of 3601 articles were identified, with 15 articles (covering 14 trials) included for extraction. There was substantial inter-relater reliability present at full-text screening (Cohen's *K* 0.625; 81% agreement). A summary of study characteristics is shown in Table 3.1.

Figure 3.1. PRISMA 2020 flow diagram - identification of studies via databases

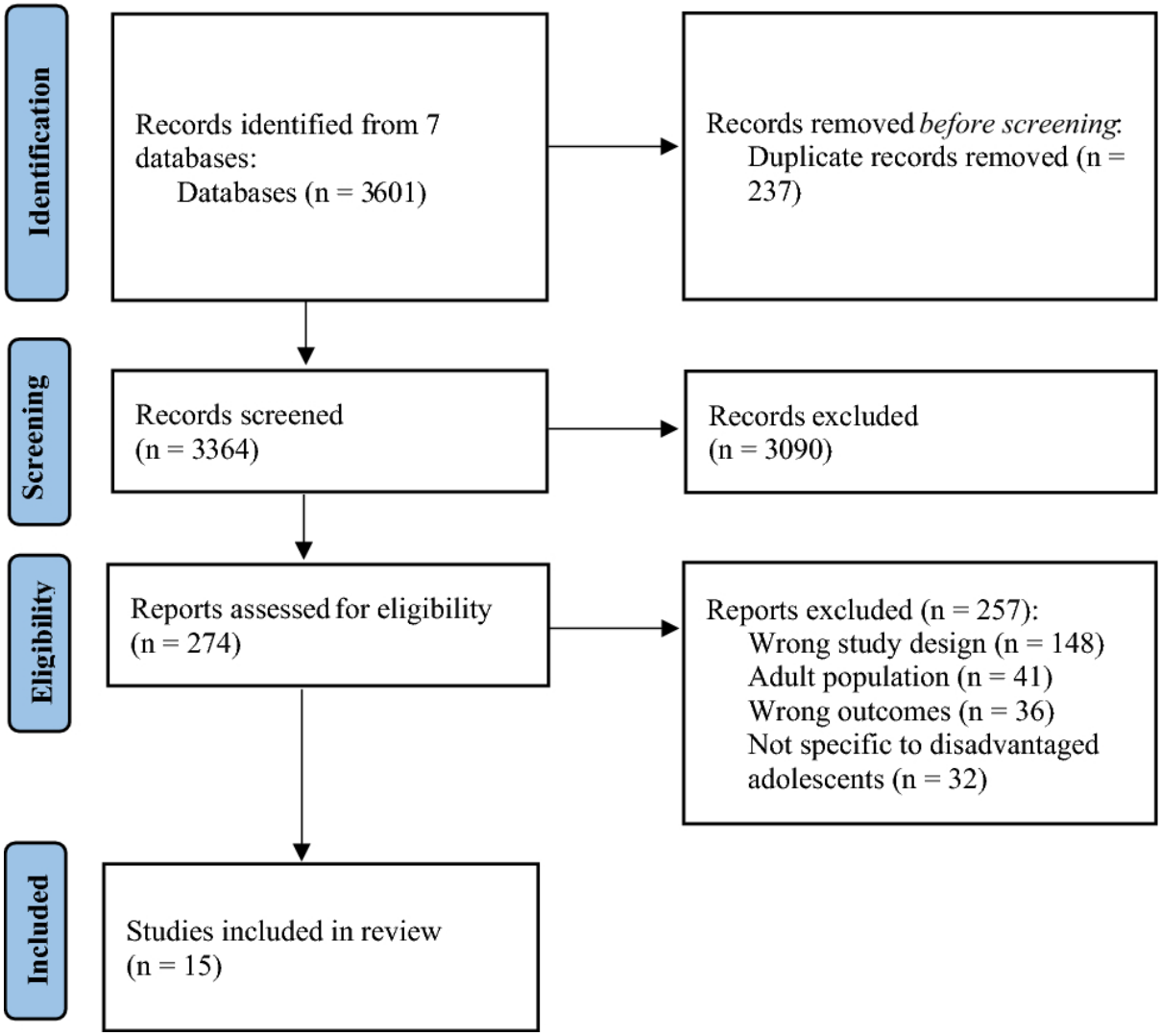


Table 3.1. Characteristics of included studies

	Study design and key sample demographics	Targeted risk behaviours	Primary outcomes	Secondary outcomes	Interventions/ mode of delivery	Measurement tools	Intervention components	Who provided	Intervention frequency and duration
Chai et al. (2021)	Three-arm pilot RCT; Australia; 1 urban and 2 rural locations; n=46 families; Children - 9 years (SD 2.3), 41% female, BMI ≥ 21.5kg/m^2; 61% urban families, 39% rural families; 15% low SES, 65% mid SES, 20% high SES	Diet, physical activity	Total dietary energy intake (kJ) and percentage energy (%E) from nutrient-rich foods (e.g. fruit and vegetables) and energy-dense, nutrient-poor foods (e.g. fried food)	Child physical activity level (PAL); Child BMI; zBMI; waist circumference	*Back2Basics* family-based intervention INT1: Telehealth-website-based with healthy cooking videos; telehealth consultations; Facebook group; INT2: Telehealth+SMS = INT1 + text messages	Objective height and weight; parent-reported FFQ (child version of Australia Eating Survey, Physical Activity Questionnaire for Children)	INT1: website education on nutrition; telehealth consultations with a dietician guided by CALO-RE taxonomy of behaviour change techniques on healthy eating behaviours; personalised dietary report and family food goals; Facebook group for parents and researchers to engage and post relevant research topics, respectively; INT2: INT1 but separate Facebook group and 42 text messages on healthy eating sent to parents	Accredited practising dietitians used the CALO-RE taxonomy of behaviour-change techniques pertaining to healthy eating for semi-structured telehealth consultation with families via videoconferencing software "Scopia". The SMS messages were informed by evidence-based literature, and refined by	INT1: 12-week access to Back2Basics website (new topics released each week) + Two 20-minute telehealth consultations; INT2: INT1 and 42 SMS delivered over 12-week study period to parents

								parents and health experts.	
Cremers et al. (2015)	Three-arm cluster RCT; The Netherlands; 162 schools; n=3213; 10.36 (SD 0.55); 50.86% female; 88.27% Western; 57.86% low SES	Tobacco smoking	Smoking behaviour (current smoker vs non-smoker)	Intention to start smoking; attitude; social influence; self-efficacy	INT1: Email and SMS prompts to use *Fun Without Smokes* website; INT2: No prompts	Online self-report survey	Wed-based, computer-tailored; online questionnaire covering participants' smoking behaviour, intention to smoke, and smoking-related sociocognitive factors (including attitude, social influence, and self-efficacy); feedback messages based on participants' responses to questionnaire via email and int website; INT1 (prompt group) received 12 prompts via email and SMS to revisit *Fun Without Smokes* website; INT2 (no prompt group) received computer-tailored feedback messages on three consecutive days with advice on smoking attitudes, perceived social influence and self-efficacy expectations to refuse cigarettes.	Online	Three self-report questionnaires (baseline, 12 and 25 months after baseline); nine tailored feedback messages (three after each questionnaire) for INT1 and INT2 groups; 12 prompt emails and SMS (six per year) for INT1 group; over 25-months
Davis et al. (2016)	Two-arm cluster RCT; USA; 11 schools in rural areas (city and/or county population	Diet, physical activity	Daily intake of calories, percent calories from fat, fruit and vegetable	Child and parent BMI; objective MVPA/day; child	INT1: Family-based telephone meetings at school in groups; INT2:	Objective height and weight; telephone survey with parents (child's 24-hour	INT1: Parent and children groups separately had telephone meetings with research team covering manualised topics focused on behaviour, nutrition	On-site representatives at each school (often a nurse, PDHPE or	14 one-hour group meetings (initially eight weekly, followed by six monthly) for

	<20,000); n=103 overweight (57.28%; 85th ≤ BMI percentile ≤ 95th) or obese children (47.72%; BMI percentile ≥ 95th) and their caregivers; 9.14 years (SD 1.86); 55.34% female; 88.24% Caucasian; 40.2% eligible for free or reduced lunch		servings, sugar-sweetened beverage servings, and servings of "red" foods (i.e. more than 12 grams of sugar and/or 7 grams of fat)	competencies and behavioural or emotional problems; mealtime behaviour problems; obesity related quality of life	Family-based telemedicine meetings at school in groups	dietary recall, accelerometers (ActiGraph); Child Behaviour Checklist (CBCL), Behavioural Pediatrics Feeding Assessment Scale (BPFAS)); child self-report of obesity related quality of life and parent-proxy report	and physical activity; INT2: Same as INT1 however sat around TV screen for audio and video communication instead of telephone	computer teacher) were trained on procedures for recruitment, consent, intervention-related activities, and taking anthropometric measurements. An intervention manual was also provided to them. Off-site leaders (a research team clinician)	parent and child groups separately, over 8-months
Frenn et al. (2003)	Quasi-experimental design; USA; two urban low-middle income schools; n=341; 12–15 years (M & SD NR); 56.9% female; 51·5% African American;	Diet, physical activity	Percentage dietary fat	Moderate-to-vigorous physical activity (past 7 days)	INT: Internet-based lessons; videos; healthy snack session; gym class	Online self-report surveys to classify participants to their respective stage of change in the Transtheoretical Model; Access to low-fat foods and	Internet-based lessons with short videos of actors acting out content; online feedback based on participants' Transtheoretical Model stage of change; online food diary with feedback; peer-led healthy snack session; peer-led physical activity gym class (one school only)	Internet and video intervention components – Online; Healthy food and exercise labs - peers under supervision from "senior nursing	Four 50-minute internet lessons; one 50-minute healthy snack session (session 4) over one school year, with one school also receiving one 50-min gym classes

	41 students eligible for free lunch and 15 reduced fee[2]					exercise areas and programs was included in survey post-test; The Food Habits Questionnaire and the Child and Adolescent Activity Log (CAAL)		students and faculty"	
Frenn et al. (2005)	Quasi-experimental design; USA; one urban public middle school; n=103 low-income, culturally diverse, seventh-grade students; 12–14 years (M & SD NR); sex NR; ethnicity NR	Diet, physical activity	Percentage dietary fat	Moderate-to-vigorous physical activity (past 7 days)	INT: internet-based lessons, videos, online discussion board, email	Online self-report survey (Staging questions for dietary behaviour and physical activity, Food Habits Questionnaire and Child and Adolescent Activity log)	Blackboard - online portal/learning management system - with four 2-3 minute videos; computer-generated tailored feedback provided based on participants' Transtheoretical Model stage of change; online discussion board; personalised email feedback	Online	Eight 40-min lessons over 1 month
Gustafson et al. (2019)	Two-arm cluster RCT; USA; 8 rural high schools; n=411; 14-16 years (M=15yrs;	Diet	Fruit and vegetable servings/day; Daily SSB intake	Body Mass Index (BMI) Z-score; home food availability;	INT: Mentor-led text messages via Group Me app or email	National Cancer Institute Fruit and Vegetable Screener, BEV-Q10	Go Big and Bring it Home (GBBH) Facebook page; Group Me mobile application or e-mail if participant did not have a mobile; affective text messages	Mentors: 34 undergraduate human nutrition and dietetics students. They	Two text messages per week over 8 weeks

[2] The National School Lunch Program in the US determines the eligibility for free lunch based on a student's SES and is a proxy for low SES

	SD NR); 64% female; 63.5% White			purchasing habits; self-efficacy; goal setting related to healthy eating		questionnaire, self-reported height and weight	including a weekly challenge related to consuming fruits, vegetables, or healthy/low-calorie beverages; tailored messages dependent on participants' response to initial message; $5 each week if participant responded to messages sent on Tuesday and Saturday; gift cards to Mentor for participating	were given 1-hour training on sending text messages through the Group Me app on Tuesday and Saturday every week over the study period and supervised by 4 Master of Science/Registered Dietician graduate students at the University of Kentucky.	
Hongthong and Areesantichai (2016)	Quasi-experimental design; Thailand; two high schools in rural Thailand; n=150 low-risk drinkers; Intervention 16.57 years (SD 0.57), 64% female,	Alcohol	NA	Alcohol knowledge	INT: *PALMSS*[3] alcohol prevention program – CD-ROM-based modules	Self-report questionnaire (modified School Health and Alcohol Harm Reduction Project (SHAHRP))	CD-ROM based modules with increasing complexity each week (1. Alcohol knowledge, 2. Low-risk drinking, 3. Social drinking, 4. Media influence, 5. Resisting peer pressure, 6. Self-efficacy); questionnaire (the Alcohol Knowledge Test)	CD-ROM	Four 50-minute modules, one delivered per week via CD-ROM over 1 month

[3] PALMSS is an abbreviation of the six core components of the program: P = peer, A = alcohol knowledge, L = low-risk drinking, M= media-influence, S = social drinking and S = self-efficacy.

	US$290.64 (SD 30.15) family income per month, ethnicity NR; Control 16.45 years (SD 0.50); 58.67% female, US$306.34 (SD 41.16) family income per month, ethnicity NR								
Lubans et al. (2016); Smith et al. (2014)	Two-arm cluster RCT; Australia; 14 schools in low-income communities; n=361 at risk of obesity; 12.7 years (SD 0.5); 100% male; Cultural background - 77% Australian, 15% European; 29% in the lowest SES band	Diet, physical activity, screen-time	SSB intake, glasses/d	Percent moderate-to-vigorous physical activity; screen-time, min/d; BMI z-score; BMI (kg.m−2); waist circumference (cm); accelerometer counts/min; grip strength, kg; push-ups	INT: *ATLAS*[4] *s*chool-based program; supplementary website and smartphone application; parent newsletters	Objective height, weight, and accelerometer counts/min; self-report survey (modified Adolescent Sedentary Activity Questionnaire, NSW Schools Physical Activity and Nutrition Survey, adapted version of	INT: School-based; teacher professional learning workshops; personal trainer delivered session; necessary fitness equipment provided; physical activity sessions; researcher delivered seminars to participants; student-led physical activity session during lunchtime; website and smartphone application to report daily step counts from pedometers, review fitness challenge results, conduct peer assessment of resistance training skill competency, set	Teachers that had completed 2x6hr professional development workshops delivered the *ATLAS* physical activity sessions to participants.	Over 20-weeks (across two school terms): two 6-hour teacher professional development workshops and 1 personal trainer session; four newsletters to parents (two each term); three 20-minute researcher-led seminars; twenty 90-minute

[4] ATLAS is an abbreviation for the multicomponent obesity prevention intervention "Active Teen Leaders Avoiding Screen-time"

				(repetitions); resistance training skill competency; Intrinsic regulation; Identified regulation; Introjected regulation; External regulation; Amotivation		Goudas et al scale); handgrip dynamometer; 90° push-up test; [researcher recorded and scored participant Resistance Training Skills Battery	goals for screen-time and physical activity; tailored motivational messages via the app based on participant responses; pedometers to self-monitor physical activity; parent newsletters with information on reducing screen-time sent via mail		ATLAS school sport sessions; six 20-minute student-led physical activity sessions during lunchtime; 15-weeks access to ATLAS app/website; 17-weeks use of pedometers
Martinez-Montilla et al. (2020)	Two-arm cluster RCT; Spain; 15 public high schools; n=1247; 16.32 years (SD 1.07); 53% female; 94.69% Spanish; 2.76% low family affluence, 32.30% medium family affluence, 64.94% high family affluence	Alcohol	Alcohol consumption (binge drinking, heavy episodic drinking, weekly consumption, any consumption)	NA	INT: *Alerta Alcohol* school-based computer-tailored lessons	Online self-report questionnaire	INT: Internet-based cartoon lessons; tailored messaging to reduce alcohol consumption and binge drinking and enhance self-esteem and awareness of risks associated with alcohol consumption and binge drinking; challenge to not drink/binge drink for upcoming event, advice and action plans; key concepts included attitude, social influences, self-efficacy and action planning	A researcher supervised all groups completing the baseline and follow-up questionnaires and a school teacher assisted participants in intervention group when required.	Six 1-hour sessions (four at school and two booster sessions at student home 1-week after third session)

Murry et al. (2019)	3-arm RCT; USA; n=421 youth & caregivers in five rural Tennessee counties (rurality index score >11 [16 or greater = most rural], 30% of residents were African American, poor health outcomes based on state health indicators e.g. health behaviours); 11-13 years (SD NR); 54% female; ethnicity NR; 14% of caregivers received public assistance	Alcohol and tobacco use	NA	Substance use (alcohol, tobacco, cannabis, cocaine, hallucinogens, methamphetamines, heroin, MDMA, or prescription drug use)[5]; Intention to engage in risk behaviours; affiliation with deviant peers; Youth vaginal, anal, and oral sexual behaviours; parenting behaviours (supportive parent–youth relationship, adaptive racial socialisation,	Promoting African American Success (PAAS) program delivered in community settings; INT1: technology (computer-based); INT2: small in-person group	Youth self-report survey (Sexual Risk Survey, Monitoring the Future scale); parent self-report survey (Carver Caregiver Support scale, Discussion Quality Scale, Racial Socialization scale, Frequency of Sexual Communication scale, Substance Use Rules Communication Scale from Strengthening Families)	INT1: Computer-based lessons (parent and youth on separate computers); off ramps and side streets demonstrate outcomes of choices and consequences; characters physically and vocally resembling members of the local community; participants choose avatars to represent themselves; family sessions (parent and youth together) discussion questions and optional viewing of video portrayal and modelling for each discussion topic; $25 for family attendance INT2: small in-person groups; concurrent parent and youth sessions followed by family sessions; role play & skill practice, group discussions and time to ask questions; videotaping sessions for fidelity	INT1: two on-site trained (6 hours of training on content and procedures) assistants INT2: trained program facilitators (36 hours of training over 6 days - often African American community members)	INT1: 6x weekly 1.5 hr sessions; INT2: 6x weekly 2hr sessions

[5] Adolescent risk behaviours (including substance use and sexual risk behaviour) were conceptualised as a composite risk score

				communication about sex, clear communication of rules and expectations about substance use)					
Nollen et al. (2014)	Two-arm randomised pilot trial; USA; n=51 low-income minority girls; 11.3 years (SD 1.6); 100% female; 83% African American, 7.8% Hispanic/Latina; 32.4% living in poverty, median annual household income US$27,388	Diet, screen-time	Fruit and vegetable consumption; sugar-sweetened beverage intake	Screen time	INT: Mobile-based modules; goal reminder and completion alarms; song	Self-report survey (24hr dietary recall*, Brief Questionnaire of Television Viewing and Computer Use) *Fruit and vegetable consumption was assessed at baseline and Week 4, and SSB was assessed at baseline and Week 8	INT: Handheld computer-based modules on fruits & vegetables, SSBs, screen time and goal setting; goal reminder and completion alarms; self-monitoring; song-based reward system (if responded to 80% of prompts)	MyPal A626 handheld computer	Over 12 weeks: two daily goals per module; reminder alarms up to three times over 6-mins at pre-selected times with tips to reach goal; one song per day if participants responded to 80% of prompts they received.
Tripicchio et al. (2017)	Quasi-experimental design; USA; urban paediatric	Diet, physical activity	NA	Fruit and vegetable consumption; servings of "red	INT1: *Healthy Hawks* in-person family-based	Parent and child self-report servings of fruit and vegetables,	INT1: 12 weekly 2-hour in-person family-based behavioural group (FBBG) program for parents and children, separated	INT1: Trained program staff INT2: Smartphone app	INT1: 12 weekly 2-hour in-person FBBG;

	clinics in Kansas City area; n=64 overweight/obese low-income youth (mean BMI percentile=98.6); 9.6 years (SD 3.1); 32.8% female; 84.4% Hispanic			foods" (i.e., high in fat and calories, poor nutritional quality); Physical activity (mins/week); BMI-z scores	behavioural group (FBBG) program; INT2: INT1 + fitness app (FITNET); INT3: INT2 + personalised health-coaching sessions via Skype	"red foods", and physical activity via self-monitoring sheets; Anthropometric data collected via trained research staff; Youth physical activity measured automatically via FITNET app; Parent daily steps recorded via pedometers	for the first hour to cover educational sessions on strategies to promote behaviour change (i.e., goal setting, self-monitoring, parent role modelling, diet/physical activity/lifestyle modification), followed by physical activity sessions; daily self-monitoring sheets for both parents and children to track servings of "red foods" (e.g. low in nutrients), fruit and vegetables, physical activity; incentive points for children if returned self-monitoring sheets each week; parents pedometers track daily steps; INT2: INT1 + fitness app (FITNET) on digital tablet for physical activity sessions at home with physical activity data automatically recorded via FITNET; INT3: INT2 + personalised health-coaching sessions via Skype on digital tablet, summary reports.	INT3: Health coach trained on protocols, motivational interviewing and modification techniques	INT2: INT1 + 30-60 min PA per week up to per day over study period; INT3: INT2 + 5x 30-min skype sessions
Voogt et al. (2013)	Two-arm cluster RCT; The Netherlands; 73	Alcohol	Heavy drinking; weekly alcohol consumption;	NA	INT: *What Do You Drink* (WDYD) brief	Online self-report survey	Part 1: Web-based intervention, screening of drinking behaviour and personalised feedback based	Online; self-guided	One 20-minute session

	classes; n=609; 17.3 years (SD 1.3); 40.1% female; ethnicity NR; 16.6% attended preparatory secondary vocational education (similar to junior high school and a prerequisite for secondary vocational education); 83.4% attended secondary vocational education (equivalent of junior college education geared towards preparing students for skilled trades /		frequency of binge drinking		web-based intervention		on screening outcomes tailored to participant sex, alcohol intake and perceived social norms; online drinking scenarios and setting drinking goals. Part 2: goal setting, action planning, and reinforcing drinking refusal self-efficacy.		

	entering the job market).[6]								
Wright et al. (2013)	Two-arm RCT; USA; one urban paediatric outpatient clinic; n=50 obese children (BMI percentile ≥ 95th) & their parents; child 10.3 years (SD 1.1), 42% female; with 72% African-American, 73.5% lower income, 52.5% high-school educated parents	Diet, screen-time	Consumption of kilocalories (kcal/wk); fat, fruits and vegetables (servings/day);	Television time hrs/wk; BMI	*Healthy Eating and Activity Today* (HEAT) parent-child telephone counselling intervention	Objective height and weight; interviewer administered questions and assessment (Block Dietary Data Systems Kids Food Screener version 2, Block 2007 Fat, Sugar, Fruit, and Vegetable screener (for parents), Youth Risk Behaviour Survey and a 12-item proxy measure (completed via parents) assessing child screen time and recreational activities); paper survey for parent	Separate parallel telephone counselling via automated interactive voice response (IVR) system for children and parents. Sessions included tailored questions, quizzes and feedback based on participants' response to IVR system; participants' responses stored in system to inform subsequent calls; vignettes and testimonials to support content using age and gender appropriate voice actors; child or parent guidebook to support calls (call topics, space to write weekly goals, track weight and foods consumed, list of community resources for PA and recreation and alternatives to TV watching); reminder call from research assistant if participants not making calls to IVR system. Data captured in calls combined with child's electronic health record (EHR) to be used by	HEAT: Telephone - automated interactive voice response system using text-to-speech EHR component: Physicians, nurses and clinical staff at the paediatric clinic	Twice a week for 12-weeks telephone counselling for parent and child, separately; EHR component: One session at 1-month post-intervention follow-up

[6] In The Netherlands higher education (bachelor/master) are called Higher Professional Education and Scientific Education.

						and child individually self-report acceptability and feasibility of HEAT.	primary care clinician in FU visit with child. Children: IVR topics included increasing consumption of green foods (low-calorie, nutrient dense) and reducing consumption of red foods (high-fat and/or high-calorie), and reducing screen time. Objectives included learning Traffic Light diet, rules, self-monitoring weight, food, screentime, and setting goals and rewards. Parents: IVR goals included: (1) having a healthy home i.e. no junk food, more green and yellow foods, creating rules related to healthy eating and screen time, asking auxiliary household members to support healthy changes; (2) good role modelling; (3) respectful child-parent relationship; (4) praising and encouraging child healthy behaviours.		

Table 3.1: (continued)

	Theoretical basis	Tailoring	Modifications	Co-designed	Comparison group	Follow-up	Process outcomes	How well/ process outcomes	Intervention Effects
Chai et al. (2021)	CALO-RE taxonomy	Both intervention groups could access the Back2Basics Family website for the entirety of the 12-week intervention, and received two 20-minute telehealth consultations with a dietician in weeks 1 and 4 of the intervention. Only the telehealth and SMS group received SMS messages, in 4-weekly rotations of decreasing frequency to	Back2Basics website content was modified from the Hunter and Illawarra Kids Challenge Using Parent Support (HIKCUPS) community-based study. HIKCUPS was previously modified to socio-economically disadvantaged areas based on focus groups with families.	Yes Online survey responses from 75 parents informed the development of additional topics and SMS content. Subsequently, 28 experts (family health researchers, health behaviour researchers, dieticians, or nutrition academics) and 20 parents (73% low-middle SES) reviewed the SMSs via an online evaluation survey.	Waitlist control	Baseline, post-intervention (3 months/12 -weeks). Retention at 12 weeks was 78% (n = 36 families; 21 intervention, 15 control). Intervention (n = 31 families): 3 families withdrew within the first month due to lack of time and 7 were lost to follow-up. Control (n = 15 families): all control families completed week 12 assessments.	Intervention fidelity; acceptability and adherence. The control group completed process evaluation survey at week 24.	Most families (96% n = 44 of 46 families) attended 1st telehealth consultation, and 78% (n = 36 of 46 families) attended 2nd telehealth consultation in week 4 of intervention. Most families (77%; n = 23) logged into the B2BF website at least once, (80%; n = 24) visited their respective Facebook group at least once, and 100% received the SMS. Only 4% (n = 2 of 46 families) of families required support with installing the videoconferencing software "Scopia". 87-100% of families reported the program was easy to use, 93% said it improved their	Significant intervention effects for primary outcomes: INT1 total energy intake was 2835 kJ less than control (p=0.026); and percentage energy (%E) in INT2 increased 11% from nutrient-rich food e.g. fruit (p = 0.045) and decreased 11% from energy-dense, nutrient-poor food (p = 0.038) compared to control group. No significant intervention effects for any of the secondary outcomes.

		determine whether they enhanced the intervention.						family/child's eating habits and 91% stated wanting to continue using the program and would recommend it to other families. Nine (60%) of control families completed the process evaluation survey at week 24.	
Cremers et al. (2015)	I-Change model	INT1 and INT2 received tailored feedback messages based on their responses to questionnaire responses at baseline, 12- and 25-months post-baseline	The original paper-based *Octopus* intervention was modified to be a web-based, computer-tailored intervention	Yes; Group interviews with 87 students aged 10-12 years informed the development of the name, colour scheme and design of the *Fun Without Smokes* intervention and website.	Assessment only	Baseline, 12- and 25-months after baseline. Attrition was 33.21% (n = 1067/3213) at 12-month follow-up, and 53.84% (n = 1730/3213) at 25-month follow-up.	NR	NR	There were no significant in intervention effects for INT1 or INT2 compared to control on any of the primary or secondary outcomes at any of the follow-up time points.
Davis et al. (2016)	Cognitive behavioural theory	NR	The original *Healthy Hawks* intervention was modified to rural family population needs	Yes; focus groups with 21 rural parents of overweight or obese children informed the modification of the *Healthy Hawks*	INT1 vs. INT2	Baseline, 8-weeks, and post-intervention (8 months). Attrition was 10%.	Telemedicine and telephone session attendance; Intervention feasibility measured on a 10-point scale with 10 equalling	Overall, 89.4% of participants attended intervention meetings. INT2 had slightly higher completion (90.82%) than INT1 (88.41%). Satisfaction following the intervention did not	There were no significant differences in groups by time for any diet or nutrition variables or for physical activity (t = 2.28, p = 0.05).

				intervention manual to include the unique barriers to achieving healthy child weight status, such as lack of weight loss resources in their community and information on self-esteem for larger body sizes.			the highest satisfaction.	significantly differ between INT1 (M = 7.77 ± 1.58) and INT2 (M = 8.33 ± 1.63). 95.74% of INT1 participants reported finding the intervention helpful in improving their child's health, compared to 93.55% of INT2 participants. Participants in both intervention groups reported being extremely satisfied with the group leaders (M = 8.93 ± 1.55), handouts (M =8.63 ± 1.39), included topics (M = 8.31 ± 1.74) and level of feedback provided (M = 8.13 ± 1.81).	Child BMI-z scores were not significantly different at 8-weeks follow-up (t = 0.91, p > 0.05) or at 8-month follow-up (t = 0.13, p > 0.05). There were no significant differences in groups by time at post-intervention for the CBCL, BPFAS, or obesity related quality of life measures.
Frenn et al. (2003)	Transtheoretical model, health promotion model	The intervention was tailored to individuals' stage of change in the Transtheoretical Model. For those in the "precontemplati	NR	No	Education as usual	Baseline, and post-intervention (1 year). Retention NR	NR	NR	Mean percentage dietary fat was not significantly different at post-intervention between intervention (31%) and control group (32%). Participation in internet sessions was associated

		on", and "contemplation" stages, intervention sessions were centred on increasing awareness of eating behaviour and exercise, advantages of a diet low in fat and exercising and barriers to engaging in these behaviours. For individuals in the "preparation", "action", and "maintenance" stage of change, the intervention was centred on preparing them to become peer role models that could lead							with a decrease in percentage dietary fat. MVPA reduced in both intervention and control groups, however, the reduction was smaller in the intervention group (-8.58 minutes) compared to the control (-37.61 minutes; p = 0.024). However, the intervention significantly increased MVPA among the lowest income for all races except Native Americans (p = 0.04).

		healthy food and exercise labs under supervision from research staff.							
Frenn et al. (2005)	Transtheoretical model, health promotion model	Personalised feedback depended on participants' stage of change according to Transtheoretical Model	NA	No	Education as usual	Baseline, and post-intervention (1 month). 77% retention	Participation in the intervention (participants completing >50% of intervention modules included in the intervention group analyses)	12 participants did not complete 50% of the physical activity intervention sessions, however, their change in MVPA levels were not significantly different to the control (t(13) = 1.53, p = .15). 6 participants did not complete the diet intervention sessions, however, they percentage of dietary fat was not significantly different to the control (t(16.6) = -1.843, p = .08).	Among participants across all racial groups with the lowest income (eligible for free lunch) intervention was effective in decreasing dietary fat and increasing physical activity. Dietary fat: Participants that completed >50% of diet sessions (n=40) decreased dietary fat from 30.7% to 29.9% t(87) = 2.73, p =-.008. PA: Participants (n=43) that completed >50% of physical activity sessions increased MVPA by 22 minutes, whereas the control

									group decreased by 46 min, t(103) = -1.99, p = .05.
Gustafson et al. (2019)	Social cognitive theory	Messages were tailored to participants dependent on how they responded (i.e. "got it" or "not yet") to the initial message sent on the Tuesday and Saturday	NR	Yes; Survey data from 432 adolescents aged 14-16 years in rural Kentucky and North Carolina that included information on their food environments informed the development of the GBBH intervention content	Waitlist control	Baseline, and post-intervention (8 weeks). Retention NR.	NR	NR	There were no significant intervention effects on SSB intake and BMI at post-intervention follow-up. Fruit and vegetable intake was significantly higher in the intervention compared to control group at post-intervention follow-up, with a mean difference 1.28 servings/day (95% CI 1.11 – 1.48). Within group analysis reported the intervention group increased 0.71 servings/day compared to a decrease of 1.52 servings/day in the control, however, results were not significant.

									There were no significant between group differences in purchasing habits, however, there were significant increases in fruit and vegetable purchases over 7-days (2.55 purchases/week, 95% CI 0.69 – 4.42), healthy snack purchases (1.81 snacks/day 95% CI 0.68 – 2.94) and water or no-calorie beverages (0.87 calories/day 95% CI 0.18 – 1.56) within the intervention group. Within the intervention group, there was a significant change in home availability of junk food ($p = 0.08$), with an increase of 8% of junk food never being available, and a reduction of 4% and 5% of junk food being

									sometimes or always available, respectively. Within the control group, there was a significant decrease of 13% in fruit and vegetables always being available, and a 6% and 7% increase in sometimes or never available, respectively ($p = 0.02$). No other within group analyses were significant. Between group analyses report a difference for home availability of fruit and vegetables ($p = 0.03$), vegetables servings at dinner ($p = 0.03$), junk food ($p = 0.01$) and soda ($p = 0.05$). Compared to the control group, the intervention group reported higher odds of having high self-

									efficacy for eating vegetables (OR 1.59, 95% CI 1.19 – 2.13), and goal setting for all dietary goals (Fruit—OR 1.52, 95% CI 1.18 – 1.95); (Vegetable—OR 1.75, 95% CI 1.19 – 2.58); and (Sugar-free beverage—OR 1.94, 95% CI 1.18 – 3.27)
Hongthong and Areesantichai (2016)	Social learning theory	NR	NR	Yes; focus groups with students and teachers guided the development of the *PALMSS* intervention	Education as usual	Baseline, post-intervention (4 weeks after baseline), 1-month, 3-month and 6-month post-intervention. Retention NR.	NR	NR	Peer drinking and GPA were significantly higher in the intervention compared to control group. After peer drinking and GPA were adjusted for, alcohol knowledge scores were significantly higher in the intervention compared to control group at 6-month follow-up ($F(1,146) = 199.11$, $p = <0.001$). However, within-subject analysis reported non-

									significant result of intervention on changes in knowledge scores over the four follow-up periods (F (3,438) = 1.87, p = 0.13).
Lubans et al. (2016); Smith et al. (2014)	Social cognitive theory, self-determination theory	Motivational messages through the *ATLAS* app were tailored to how the student responded to their reasons for being motivated to be physically active at the start of the intervention.	The *Physical Activity Leaders* (PALS) pilot study informed the design of the *ATLAS* study to include increased diversity of activities and increased movement skill development.	No	Education as usual	Baseline, post-intervention (8-months) and 10-months post-intervention (18-months from baseline). Retention: 81.2% (n= 293) at 8-months follow-up, and 73.7% (n = 266) at 18-months follow-up.	Intervention implementation; school sport session fidelity; attendance at sessions; participant engagement with app and pedometers; intervention satisfaction	Across intervention schools, 79% ± 15% implemented the *ATLAS* sport sessions and 64% ± 40% implemented the lunchtime mentoring sessions. Adherence to the *ATLAS* sport session structure across 4 observation periods was 61%, 58%, 90%, and 96%. 65% of participants attended ≥70% of *ATLAS* sport sessions, however, only 44% attended at least two-thirds of lunchtime sessions. 63% of participants used the ATLAS app and 25% used the ATLAS website. 70% of participants used	SSB intake was significantly less in the intervention group (mean: = -0.6 ± 0.26 glass/d; p = .01) compared to control at 8-month follow-up. However, this effect was not sustained at 18-month follow-up. There was a significant intervention effect on screen-time (mean: –30 ± 10.08 min/d; p = .03), muscular fitness (mean: 0.9 ± 0.49 repetition; p = .04), and resistance training skills (mean: 5.7 ± 0.67 units; p < .001).

								the goal setting function to increase physical activity or reduce screen-time. 62% monitored resistance training via the ATLAS app, and 49% monitored pedometer steps and fitness challenge results. On a scale of 1 to 5, with 5 being the highest, a high proportion of participants were satisfied with *ATLAS* (mean: 4.5 ± 0.7) and enjoyed the sport sessions (mean: 4.5 ± 0.7). Satisfaction scores for the lunchtime sessions were lower (mean: 3.7 ± 1.0). Nearly 50% of participants agreed or strongly agreed the "push prompts" reminded participants to consume less SSBs and reduce screen-time. 44% agreed or strongly agreed that they enjoyed using the *ATLAS* app. Satisfaction with *ATLAS* was high	At 18-months follow-up there were only intervention effects on screen-time, resistance training skill competency and motivational regulations for school sport. 18-month follow-up group-by-time analyses showed an interaction effect for screen-time (mean = −32.2 mins/day, 95 % CI = −53.6 to −10.8, p = .003), resistance training skill competency (mean = 5.9 units, 95 % CI = 4.5 to 7.3, p < .001), intrinsic, identified, introjected and external regulations range of adjusted differences between groups between 0.40 units to

								among teachers (mean: 4.4 ± 0.5), including enjoying professional development workshop 1 (mean: 5.0 ± 0.0) and 2 (4.9 ± 0.4).	0.56 units, $p < 0.05$ for all.
Martinez-Montilla et al. (2020)	I-Change model	The messages delivered to participants through the *Alerta Alcohol* cartoon stories depended on which main character the participant chose	The original *Alcohol Alert* intervention developed in The Netherlands was culturally modified to the Spanish context to reflect differences in cultural issues related to alcohol consumption, knowledge and risk perception of alcohol consumption, and motivational factors (e.g.	Yes; 14 focus groups with adolescents aged 16 to 18 years, in addition to focus groups with fathers / mothers, and a Delphi expert group informed the development of *Alerta Alcohol* content including character stories adapted to gender and age and tailored health messages.	Waitlist control	Baseline, and 4-months after baseline. Attrition was 50.92% (n = 612) at 4-months follow-up.	Intervention adherence; acceptability and satisfaction	Of the 742 participants that completed the first session, 461 (62.1%) completed the second, 350 (47.2%) completed the third session at school. 23 (3.1%) and 8 (1.1%) completed the fourth and fifth sessions at home. Of the 295 participants that completed process evaluation questions, 150 (50.8%) said the sessions were too long. 223 (76.1%) reported the advice content was credible, 185 (63.1%) said it was understandable, 185 (63.1%) said it was useful, and 177 (60.0%) said it was interesting. 203 (68.8%) were satisfied with *Alerta Alcohol*, 155 (52.9%) reported intention	With the exception of heavy episodic drinking in favour of the intervention (OR 9.129, 95% CI 1.107-75.259, p =.04), there were no significant between group intervention effects on alcohol consumption outcomes. Logistic regression analyses showed that at follow-up, compared to participants of high family affluence, participants with medium family affluence were more likely to binge drink (OR 3.365, 95% CI 1.058-10.704, P=.04), and participants of low

			attitude and social influences).					to use it again, and 184 (62.8%) would recommend it to someone else.	family affluence were more likely to have consumed any alcohol (OR 1.801, 95% CI 3.289-0.987, P=.06)
Murry et al. (2019)	NR	NR	Based on ethnographic research on the availability of computers in the local communities, the original *Strong African American Families Program* (SAAF) intervention was modified to be delivered via computer for rural African American families	Yes; interviews with 40 interviewers (African American community members) informed the development and refinement of study measures and procedures	Non-interactive content (hardcopy version of intervention content)	Baseline, post-test [M = 14.5 (4.4) months after pre-test] and long-term follow-up [M = 22.6 (3.7) months after post-test]. Retention: 337 (80%) at post-test follow-up, and 165 (39%) at long-term follow-up.	INT2 fidelity assessed via random selection of videotaped sessions - interrater reliability >80% for parent, youth and family sessions, and fidelity to curriculum >80%.	NR	Risk behaviour among youth significantly decreased over time in INT1 (β = -.17; 95% CI=-31 to -.04; p = .04), however, was not significant in INT2 (β = -.05; 95% CI = -.20 to .11; p = .58). Behavioural intentions to engage in risk behaviours significantly decreased over time in INT1 (β = -.12; 95% CI = -.20 to .01; p = .04). However, affiliation with deviant peers significantly increased over time in INT2 (β = -.16; 95% CI = .06 to .27; p = .002).

Nollen et al. (2014)	Behaviour change principles including goal setting, self-monitoring and cues to action	NR	NR	Yes; Important themes were developed in four meetings with a 12-member community advisory board including staff members from the Young Women's Christian Association (YWCA) of Greater Kansas City, parents, teachers, health care professionals, and professionals from other organisations promoting health and wellness among adolescent girls. Two focus groups with a 15-member student advisory board gave feedback on using personal	Hardcopy manual version of intervention content without prompts to use, action cues or a reward system	Baseline, weeks 4, 8 and 12 of intervention Retention was 86.2% at week 12 follow-up (n = 44). 7 lost to follow-up (3 intervention, 4 control).	Intervention enjoyment and use	Participants engaged with the program on 63% of days, answered 42% of prompts, and earned approximately 23.9 songs. Intervention had a mean enjoyment score of 4.5 (SD 0.9), with favourite components being the songs (68.2%), and goal setting (36.4%). The least liked component was the reminder prompts (31.8%). Program use was associated with SSB (*r* = 0.50, p = 0.01), however, not significant for fruit and vegetable servings or screen time. At 8-week follow-up, participants responding to more prompts had greater reductions in SSBs compared to those responding less (mean difference = -0.31 daily servings).	Within group analyses reported the intervention group increased fruit and vegetable consumption (p = 0.08) and decreased SSBs (p = 0.09). Between group analyses reported the intervention ate 1 more servings of fruit and vegetables (p = 0.13) and 0.35 less servings of SSBs (p = 0.25) with Cohen's d = 0.44, and -0.34, respectively. No significant intervention effects on screen time or BMI.

				digital assistant (PDA) technology to deliver an intervention delivery, and the development of future intervention phases/prototypes.					
Tripicchio et al. (2017)	N.R. Behaviour change strategies included goal setting, feedback and personal tailoring and motivational interviewing.	INT2: FITNET provided personal tailoring of physical activity INT3: health coaching Skype sessions were individually tailored to families	INT2 & INT3 were added to the existing Healthy Hawks intervention (FBBG)	No	Pre-post within group comparisons Between group comparisons	Baseline and post-intervention (12 weeks). Retention: FBBG 66.7%, INT2 80%, and INT3 78.3% ($\chi 2 = 1.2$, $p = 0.56$)	Weekly FBBG attendance; acceptability and use of FITNET and telemedicine sessions	Out of the 12 weekly FBBG sessions, INT1 attended the most (10.3 ± 1.11), followed by INT3 (9.6 ± 2.0) and INT2 (9.4 ± 2.0). FITNET total usage in minutes was significantly higher among INT3 (425.4 ± 275.6) than INT2 (225.2 ± 148.4) ($F = 5.6$, $p = 0.02$). All of INT3 completed at least 1 Skype session, and 44.5% completed 5 sessions ($M = 3.4 \pm 1.7$). Overall, acceptability of FITNET and Skype was rated highly.	INT3 was the only group with significant changes in BMI-z postintervention ($\beta = -0.09(0.02)$, $p < 0.001$). INT1: $\beta = -0.05(0.04)$, $p = 0.25$; INT2: $\beta = -0.006(0.06)$, $p = 0.92$ Telemedicine use was significantly associated with BMI-z reduction ($\beta = -0.04(0.01)$, $p = 0.01$)

								FITNET: Among those that completed the FITNET acceptability survey, participants in INT2 reported intention to use FITNET post-intervention if available, and INT3 reported FITNET was helpful for increasing and maintaining PA Skype: 90% of INT3 parents said the sessions were "very" or "extremely" helpful for their children to reach health goals (M= 4.3 ± 0.7), and 100% said they were equally as helpful for them to reach personal health goals (M= 4.4 ± 0.5). All parents reported they were "very" or "extremely" enthusiastic to recommend the sessions to other families (M= 4.8 ± 0.5).	
Voogt et al. (2013)	I-Change model, motivational	In part 1 of intervention, the participant	The original WDYD intervention	No	Assessment only	Baseline, and 1- and 6- months follow-up.	NR	NR	There were no significant intervention effects on weekly

	Interviewing principles	received personalised feedback based on their sex, alcohol intake and perceived social norms.	was slightly modified in terms of usability (i.e., use of language) to target adolescents and young adults between the ages of 15–20 years with a low educational background.			Attrition rates were 35.5% (n = 216, 134 in the intervention condition and 82 in the control condition) and 54.0% (n = 329, 188 in the intervention condition and 141 in the control condition) at one- and six-months follow-up.			alcohol consumption, heavy drinking and frequency of binge drinking at 1- and 6-months follow-up. The results were replicated in a completers-only analysis with the exception of frequency of binge drinking at 1-month which showed that 55.7% of the intervention drank 5+ glasses compared to 66.7% in the control (*OR* = 0.85; *CI* = 0.73 to 0.98; NNT = 11; *p* = 0.03). Gender, age, educational level and readiness to change had no significant moderating effect between the intervention and alcohol outcomes at any follow-up period.

Wright et al. (2013)	Social cognitive theory	Tailored feedback was provided to participants based on their responses to the IVR system questions.	NR	No	Waitlist control	Baseline and 3-months post baseline; Retention was 86% at follow-up (intervention n = 21/24 [87.5%]; control n = 22/26 [84.6%])	Feasibility and acceptability of intervention	Feasibility of IVR: 17/21 children (81%) called the IVR system at least once. The mean number of total calls was 9.0 (averaging 6.2 for the education and 2.8 for the monitoring calls). Acceptability of IVR: Most children reported HEAT was easy to use, helpful, trustworthy, designed appropriately for people like them, and supported them eat healthy foods. Only 35% said it supported them reduce screen time. 83% of children said they would recommend HEAT to a friend, 82% reported liking HEAT as it could be used at home, 59% reported liking HEAT as it could be accessed over the phone, and approximately 50% reported preferring using HEAT via a website.	No significant between group differences on adolescents' total consumption of kilocalories (kcal/wk), fat, fruits and vegetables (servings/day). Television time was significantly less among the intervention compared to control at follow-up (mean difference: -2.0 hrs/d; p = 0.05). There were no intervention effects on BMI.

3.5.1. Study Characteristics

Across the 14 trials, 7170 youth aged between 9 and 18 years took part, with an average of 50.1% female (for studies reporting sex), and 56% low-mid SES, and 33% remote. Trials predominantly included both males and females, with the exception of two trials that evaluated solely a male population (Lubans et al., 2016; Smith et al., 2014) and female population (Nollen et al., 2014). Studies were predominantly conducted in the USA ($n = 8$; 57%), and study designs included cluster randomised controlled trials ($n = 6$; 43%), randomised controlled trials ($n = 4$; 29%) and quasi-experimental studies ($n = 4$; 29%). Sample sizes ranged from 46 to 3213 adolescents, with intervention length varying between 20 min to 25-months and follow up periods ranging from one month to 25-months. Comparators were most commonly education as usual ($n = 4$; 29%) or waitlist control ($n = 4$; 29%), however, two studies (14%) did not have a control group, and instead examined between group comparisons.

Nine trials (Cremers et al., 2015; Frenn et al., 2003; Frenn et al., 2005; Lubans et al., 2016; Martinez-Montilla et al., 2020; Nollen et al., 2014; Smith et al., 2014; Tripicchio et al., 2017; Voogt et al., 2013; Wright et al., 2013) were conducted among adolescents of low socioeconomic status, four (Chai et al., 2021; Davis et al., 2016; Gustafson et al., 2019; Hongthong & Areesantichai, 2016) were among adolescents living in geographically remote areas, and one focused on adolescents of both low socioeconomic and geographically remote backgrounds (Murry et al., 2019).

Nine trials (Chai et al., 2021; Davis et al., 2016; Frenn et al., 2003; Frenn et al., 2005; Gustafson et al., 2019; Lubans et al., 2016; Nollen et al., 2014; Smith et al., 2014; Tripicchio et al., 2017; Wright et al., 2013) targeted diet, three (Hongthong & Areesantichai, 2016; Martinez-Montilla et al., 2020; Voogt et al., 2013) targeted alcohol, one (Cremers et al., 2015) targeted tobacco, and one (Murry et al., 2019) targeted both alcohol and tobacco. No studies targeted vaping.

3.5.2. Intervention Characteristics

Most interventions were either standalone eHealth ($n = 11$ Chai et al. (2021); Cremers et al. (2015); Davis et al. (2016); Frenn et al. (2005); Gustafson et al. (2019); Hongthong and

Areesantichai (2016); Martinez-Montilla et al. (2020); Murry et al. (2019); Nollen et al. (2014); Voogt et al. (2013); Wright et al. (2013)) or mainly eHealth (*n* = 1 Frenn et al. (2003)) interventions, and primarily used computer-based methods (e.g., websites) to deliver the intervention, followed by telephone (including SMS), and telemedicine (e.g., Skype).

Twelve studies cited theoretical underpinnings for their interventions, most commonly Social Cognitive Theory (*n* = 3; 21%) and the I-Change Model (*n* = 3; 21%). Eight studies (Chai et al., 2021; Cremers et al., 2015; Davis et al., 2016; Gustafson et al., 2019; Hongthong & Areesantichai, 2016; Martinez-Montilla et al., 2020; Murry et al., 2019; Nollen et al., 2014) (57%) evaluated an intervention that was co-designed with end users and key stakeholders (including at least one of the following groups: adolescents; teachers; parents; community members; health care professionals).

3.5.3. Primary Outcomes

Primary outcome data relating to poor diet, alcohol use and tobacco smoking for each trial is shown in Table 3.1.

3.5.3.1. Dietary Intake

Of the eight trials assessing dietary outcomes, compared to a control group three eHealth interventions were significantly associated with: increased fruit and vegetable intake (Gustafson et al., 2019) at post-intervention; decreased SSB consumption at post-intervention (8-months) but not 18-month follow-up (Lubans et al., 2016; Smith et al., 2014); reduced total energy intake in a telehealth only-based intervention group, and percentage energy increase of nutrient-rich food e.g. fruit and decrease of nutrient-poor food in a telehealth plus SMS group (Chai et al., 2021).

Three trials reported non-significant between group differences on: fruit and vegetable consumption and SSB intake compared to control (Nollen et al., 2014); daily intake of calories, percent calories from fat, fruit and vegetables, SSBs, and nutrient-poor foods between a telephone-based to telemedicine-based intervention (Davis et al., 2016); and adolescents total consumption of kilocalories (kcal/wk), fat, fruits and vegetables (servings/day) compared to control (Wright et al., 2013).

Finally, two trials (Frenn et al., 2003; Frenn et al., 2005) assessed intervention effects on percentage dietary fat, with one reporting no significant difference between intervention and control groups at post-intervention (1-year) (Frenn et al., 2003).

3.5.3.2. Alcohol & Tobacco Use

Of the three trials assessing alcohol consumption and tobacco smoking, one trial (Martinez-Montilla et al., 2020) reported a reduction in heavy episodic drinking at 4-months post-baseline among the whole study sample. Compared to participants of high family affluence, those of medium family affluence were significantly more likely to binge drink, and those of low family affluence were more likely to have consumed any alcohol (although results were not significant $p = 0.6$).

Two trials (Martinez-Montilla et al., 2020; Voogt et al., 2013) found no significant intervention effects on binge drinking, any or weekly alcohol consumption,—although one (Voogt et al., 2013) conducted analysis on participants that completed the intervention only and reported a significant reduction in binge drinking at 1-month follow-up compared to control –, and another (Cremers et al., 2015) found no intervention effects on smoking behaviour.

3.5.4. Secondary Outcomes

Secondary outcomes data reported in each trial is presented in Table 3.1. Five trials assessed intervention effects on moderate to vigorous physical activity (MVPA) (Chai et al., 2021; Davis et al., 2016; Frenn et al., 2003; Frenn et al., 2005; Lubans et al., 2016; Smith et al., 2014), however, only one trial reported a significant increase in MVPA (Frenn et al., 2005). Three trials assessed intervention effects on screen-time (Lubans et al., 2016; Nollen et al., 2014; Smith et al., 2014; Wright et al., 2013), with two reporting significant reductions (between -30 min/day to -2 h/day) in screen-time (Lubans et al., 2016; Smith et al., 2014; Wright et al., 2013).

One trial (Murry et al., 2019) conceptualised adolescent risk behaviours (substance use and sexual risk) as a composite risk score and found the computer-based intervention was associated with a significant decrease in risk behaviours and intentions to engage in risk behaviours (including alcohol and tobacco use) over time. Contrastingly, another trial (Cremers et al., 2015), reported no significant reduction in tobacco smoking intentions.

In the one trial (Hongthong & Areesantichai, 2016) that assessed intervention effects on alcohol knowledge, it reported significantly increased alcohol knowledge scores in the intervention group compared to control group at 6-month follow-up after adjusting for peer drinking and GPA.

Finally, seven trials (Chai et al., 2021; Davis et al., 2016; Gustafson et al., 2019; Lubans et al., 2016; Nollen et al., 2014; Smith et al., 2014; Tripicchio et al., 2017; Wright et al., 2013) assessed intervention effects on BMI, however, only one trial (Tripicchio et al., 2017) was associated with reduced BMI-z scores at post-intervention (12-weeks) among a app and telemedicine-based intervention group. However, between group differences were not significant.

3.5.5. Factors Associated with Intervention Effectiveness

For studies with significant intervention effects on primary outcomes (Chai et al., 2021; Gustafson et al., 2019; Lubans et al., 2016; Martinez-Montilla et al., 2020; Smith et al., 2014; Voogt et al., 2013), intervention length ranged from one 20-min session to 8-months, included personalised feedback to participants, and Social Cognitive Theory was most common when targeting poor diet, and I-Change Model was most common when targeting alcohol use.

Generally, studies reporting non-significant intervention effects on primary outcomes (Cremers et al., 2015; Davis et al., 2016; Frenn et al., 2003; Nollen et al., 2014; Wright et al., 2013) were either delivered via telephone or telemedicine, or did not provide personalised feedback, with intervention length ranging from 12-weeks to 1-year. There were no clear differences in intervention effects on primary outcomes when comparing programs that were co-designed (Chai et al., 2021; Cremers et al., 2015; Davis et al., 2016; Gustafson et al., 2019; Martinez-Montilla et al., 2020; Nollen et al., 2014) versus those that were not (Frenn et al., 2003; Frenn et al., 2005; Lubans et al., 2016; Smith et al., 2014; Voogt et al., 2013; Wright et al., 2013).

Intervention effects on primary outcomes for trials specifically designed for disadvantaged adolescents (Chai et al., 2021; Davis et al., 2016; Frenn et al., 2003; Gustafson et al., 2019; Lubans et al., 2016; Nollen et al., 2014; Smith et al., 2014; Voogt et al., 2013) versus those that conducted sub-group analyses (Cremers et al., 2015; Frenn et al., 2005; Martinez-Montilla et al., 2020; Wright et al., 2013) were similar, with four (Chai et al., 2021;

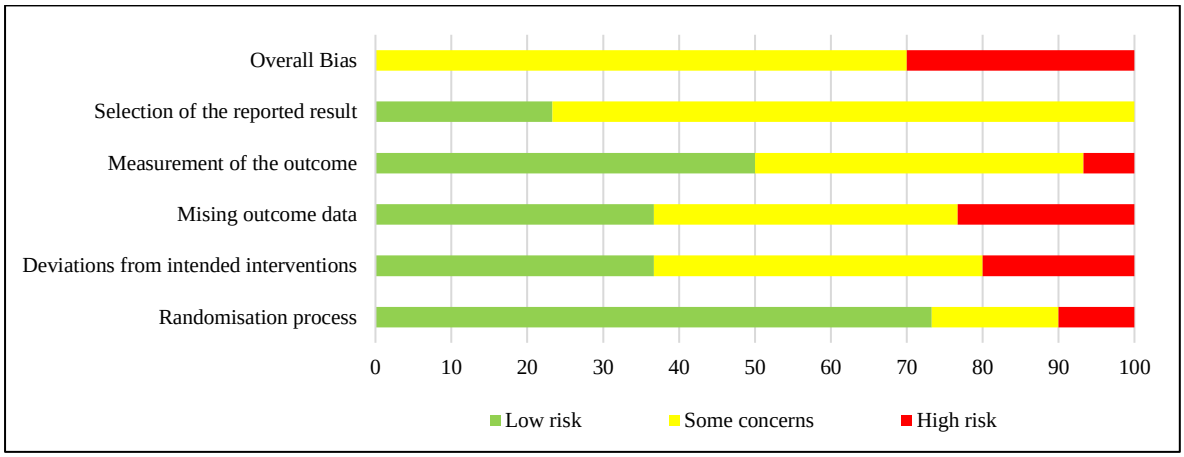
Gustafson et al., 2019; Lubans et al., 2016; Smith et al., 2014; Voogt et al., 2013) of ten trials, and one (Martinez-Montilla et al., 2020) of four, reporting significant intervention effects, respectively.

Three trials reported participants' participation in the intervention was associated with higher reductions in dietary fat and increased physical activity (Frenn et al., 2005), decreased BMI-z scores (Tripicchio et al., 2017) and SSB consumption (Nollen et al., 2014). Of the six trials (Davis et al., 2016; Lubans et al., 2016; Martinez-Montilla et al., 2020; Nollen et al., 2014; Tripicchio et al., 2017; Wright et al., 2013) that assessed participant satisfaction with the intervention, generally interventions were rated highly. Participant retention did not appear meaningfully different between interventions reporting significant results versus those that did not, and only two studies (Cremers et al., 2015; Martinez-Montilla et al., 2020) reported participant retention below 50% at post-intervention follow-up.

3.5.6. Risk of Bias

A summary of the overall risk of bias assessment for included papers is shown in Figure 3.2. Of the 15 included articles, seven studies were rated as having high risk of overall bias for at least one outcome (Chai et al., 2021; Cremers et al., 2015; Frenn et al., 2003; Martinez-Montilla et al., 2020; Nollen et al., 2014; Smith et al., 2014; Tripicchio et al., 2017), and several studies were rated as having unclear overall risk of bias for at least one outcome (Chai et al., 2021; Davis et al., 2016; Frenn et al., 2005; Gustafson et al., 2019; Hongthong & Areesantichai, 2016; Lubans et al., 2016; Murry et al., 2019; Smith et al., 2014; Voogt et al., 2013; Wright et al., 2013). These ratings were predominantly driven by missing outcome data (i.e. not examining differences between participants lost to follow-up and those that completed follow-up assessments) and deviations from intended interventions (i.e. blinding often was not possible and in some studies intention-to-treat analysis was not employed). Furthermore, most studies failed to reference a published protocol, and were therefore rated has having an unclear risk of selective reporting of the result.

Figure 3.2. Overall risk of bias assessment for included studies



3.6. Discussion

Chronic disease burden disproportionately affects disadvantaged adolescents including those from low socioeconomic and geographically remote backgrounds. A critical and cost-effective approach towards reducing the risk of experiencing chronic disease burden across the lifetime, is preventing lifestyle risk behaviors such as poor diet, alcohol use, tobacco smoking and vaping in adolescence, that is ideally prior to their onset and entrenchment. There is considerable evidence to support the efficacy of universal eHealth interventions among adolescents in delaying or preventing modifiable risk behaviors. This is the first study, however, to systematically review the effectiveness of eHealth interventions targeting adolescents living in geographically remote and/or of lower socioeconomic contexts in preventing poor diet, alcohol use, tobacco smoking and vaping.

As adolescence is a key formative period of development that can have lasting effects on future health, it is critical prevention interventions are delivered prior to the initiation and uptake of lifestyle risk behaviours that may lead to subsequent development of chronic disease in adulthood. Interestingly, this study found that although the age range of adolescents from disadvantaged backgrounds in included studies varied from 9 to 17 years, generally adolescents were older (average 14 years) in studies reporting significant intervention effects related to poor diet, alcohol and tobacco use (Chai et al., 2021; Gustafson et al., 2019; Hongthong & Areesantichai, 2016; Lubans et al., 2016; Martinez-Montilla et al., 2020; Murry et al., 2019; Smith et al., 2014; Voogt et al., 2013), compared to those that were not (average 11 years) (Cremers et al., 2015; Davis et al., 2016; Frenn et al., 2003; Frenn et al., 2005; Nollen et al., 2014; Tripicchio et al., 2017; Wright et al., 2013). It appears that

older adolescents are more receptive to eHealth interventions, which may be reflective of developing greater autonomy over their life (Spear & Kulbok, 2004). However, it is important that future longitudinal studies assess the long-term effects of eHealth interventions across adolescence.

Another key point to consider with regard to interventions aimed at preventing lifestyle risk behaviours among disadvantaged adolescents, is delivering interventions that pay attention to contextual factors including socioeconomic status and geographic location as they may potentially influence the efficacy of programs. In this study, the distribution of studies was largely skewed towards focusing on adolescents of low socioeconomic backgrounds, and were predominantly aimed at preventing poor diet, followed by alcohol use and tobacco smoking. Relatively fewer studies targeted adolescents living in geographically remote areas. Only one study targeted adolescents of both low socioeconomic and geographically remote contexts in preventing alcohol use and tobacco smoking. No studies targeted vaping. Of the 15 articles that were analysed in this study, five (Chai et al., 2021; Gustafson et al., 2019; Lubans et al., 2016; Martinez-Montilla et al., 2020; Smith et al., 2014; Voogt et al., 2013) reported significant intervention effects relating to improved dietary behaviours, and reduced alcohol use and tobacco smoking.

Of the six studies targeting adolescents of low socioeconomic backgrounds in preventing poor diet, only one was associated with decreased SSB consumption immediately post-intervention, however, intervention effects were short-lived with non-significant results at longer-term follow-up (Lubans et al., 2016; Smith et al., 2014). This finding is consistent with a recent review (Champion, Parmenter, McGowan, Spring, Wafford, Gardner, Thornton, McBride, Barrett, Teesson, & Newton, 2019) of eHealth multiple health behaviour change interventions. Although a smaller number of studies targeted adolescents living in geographically remote areas, two of the three were associated with improved dietary outcomes at post-intervention. Specifically, they reported significant intervention effects on increasing fruit and vegetable intake and percentage energy increase of nutrient-rich food, and decreasing total energy intake, energy-dense, nutrient-poor food percentage energy consumption (Chai et al., 2021; Gustafson et al., 2019). Considering these three studies together, they were most commonly guided by Social Cognitive Theory, were specifically designed for disadvantaged adolescents, and included personalised feedback to participants.

For studies not associated with improved dietary outcomes, it is possible that the lack of personalised feedback to participants hindered significant intervention effects in two studies (Davis et al., 2016; Nollen et al., 2014) or the study length and/or intervention dose was not sufficient to achieve larger effect sizes. For instance, in one study (Frenn et al., 2003) four 50-min internet-based lessons and one 50-min peer-led healthy snack session were delivered over one year. As the only assessment was conducted at post-intervention (1-year), there is the potential that intermediary intervention effects may have been missed, or lessons were too infrequent for participants to consolidate and apply learning. Given two of these studies found participation was associated with decreased percentage dietary fat (Frenn et al., 2003) and a larger reduction in SSB consumption (Nollen et al., 2014), this suggests additional modules were required. This is in line with a previous review of eHealth interventions targeting diet and physical activity, reporting greater intervention dose and utilisation tended to improve health behaviour change (Norman et al., 2007). Together these study components may have enhanced the effectiveness of the interventions. The overall risk of bias ratings for studies targeting poor diet included four studies as having high risk of overall bias on at least one outcome (Chai et al., 2021; Frenn et al., 2003; Nollen et al., 2014; Smith et al., 2014), and seven studies as having unclear overall bias on at least one outcome (Chai et al., 2021; Davis et al., 2016; Frenn et al., 2005; Gustafson et al., 2019; Lubans et al., 2016; Smith et al., 2014; Wright et al., 2013). Key domains contributing to these ratings included high risk of bias on deviations from intended interventions (due to blinding of intervention groups often not being possible) and missing outcome data, and unclear risk of bias for selective reporting of result.

Turning to studies that targeted alcohol use only, only two were included in this study and both were among adolescents of low socioeconomic backgrounds (Martinez-Montilla et al., 2020; Voogt et al., 2013). The first (Martinez-Montilla et al., 2020) found adolescents of lower family affluence were more likely to report consumption of any alcohol (although not significant $p = 0.6$), and a significant association between family affluence and binge drinking at 4-months post-baseline among the whole study sample. The other (Voogt et al., 2013) reported significant intervention effects on binge drinking at 1-month follow-up among completers only. Although both studies were guided by the I-Change Model and included personalised messaging or feedback to participants, they differed in intervention dose and specific tailoring to disadvantaged adolescents. The first consisted of six one-hour sessions and conducted a sub-group analysis by family affluence. The second included one twenty-

minute session and was specifically tailored to adolescents of low socioeconomic backgrounds. Interestingly, other universal studies have only found positive outcomes relating to the frequency of binge drinking at longer-term follow-up timepoints (i.e. 6- to 12-months, rather than immediately post-intervention) (Newton et al., 2010; Vogl et al., 2009) suggesting specifically tailored programs may yield more immediate enhanced program efficacy. The overall risk of bias was high for one (Martinez-Montilla et al., 2020) of these studies mainly due to missing outcome data (i.e. no sensitivity analysis) and measurement of the outcome (i.e. self-report), and unclear for the other (Voogt et al., 2013) largely due to measurement of the outcome (i.e. self-report). As no studies targeted adolescents living in geographically remote backgrounds, these findings underscore a crucial need for future research, particularly as consumption of alcohol at risky levels tends to be higher among adolescents living in geographically remote areas (Marqués-Sánchez et al., 2020).

Considering interventions targeting tobacco use, none were targeted at adolescents living in geographically remote areas. This is concerning given tobacco smoking is generally higher among adolescents living in geographically remote areas than their counterparts (Warren et al., 2017). Unlike the abovementioned interventions targeting alcohol use reporting significant intervention effects that were also underpinned by the I-Change Model, the one study (Cremers et al., 2015) that targeted tobacco use only was not associated with a reduction of smoking behaviour or intentions. Additionally, participant retention was less than 50% at post-intervention follow-up. This study (Cremers et al., 2015) was rated as having high overall risk of bias predominantly due to missing outcome data (i.e. significant differences in participants lost to follow-up). In view of these findings, consideration of alternative theories for tobacco use prevention interventions is warranted. For instance, eHealth interventions grounded in Social Cognitive Theory show promise in reducing tobacco smoking among adolescents with higher retention rates (Champion et al., 2013; Skov-Ettrup et al., 2014).

Concerningly, no studies targeted vaping. Although the proportion of adolescents initiating tobacco use is generally declining, the same cannot be said for vaping, and suggests the motivators for tobacco smoking and vaping are dissimilar among adolescents (Dutra & Glantz, 2014; Wills et al., 2016). Effective theories for interventions targeting tobacco use may not translate to those targeting vaping. Indeed, findings from a recent review recommended the delivery of prevention strategies targeting vaping be set-apart from tobacco

use and underpinned by behaviour change theories (Liu et al., 2020). Nevertheless, as no study has specifically targeted vaping among disadvantaged adolescents, future research is needed to examine the mechanisms of change in these behaviours.

Despite relatively few studies reporting significant intervention effects on primary outcomes, this review found positive effects on secondary outcomes in six studies including increased alcohol knowledge (Hongthong & Areesantichai, 2016) and MVPA (Frenn et al., 2005), decreased screen-time (Lubans et al., 2016; Smith et al., 2014; Wright et al., 2013), BMI-z scores (Tripicchio et al., 2017), and engagement and intentions to engage in risk behaviours (including alcohol and tobacco use) (Murry et al., 2019). These behaviours are important protective factors for chronic disease risk (Ezzati & Riboli, 2013), thus make a substantial contribution to supporting disadvantaged adolescents achieve improved future health outcomes. Moreover, several factors associated with intervention effectiveness (e.g. most effective theories for targeting specific health behaviours, delivery method and frequency, inclusion of personalised feedback) were identified in this review. However, it is worth highlighting that although effectiveness in intervention outcomes appeared similar between studies incorporating co-design versus those that did not, previous research has found interventions that have not been tailored to disadvantaged populations are associated with poor engagement and impact, and may contribute to greater health inequalities (Coupe et al., 2018). Co-design facilitates incorporation of the intended audience's experiences and perspectives into an intervention, and informs the type of content, delivery method, and key components to ensure its accessibility (Holly et al., 2022; WHO, 2020c). The importance of incorporating co-design into future interventions should be considered to adequately address the unique barriers disadvantaged adolescents experience and deliver effective and appropriate interventions.

The results indicate the need for future research on effective eHealth interventions among disadvantaged adolescents due to the paucity of studies identified and intervention effects on primary outcomes limited to those targeting poor diet and alcohol use only.

There are several strengths to this study. First, this study has provided a more up-to-date review of the literature on eHealth interventions, which is a rapidly developing area of research. For instance, compared to the Champion, Parmenter, McGowan, Spring, Wafford, Gardner, Thornton, McBride, Barrett, Teesson and Newton (2019) systematic review that

looked at eHealth interventions targeting poor diet, alcohol use and tobacco smoking, this systematic review differed in that it: utilised a targeted search to capture adolescents living in geographically remote and/or lower socioeconomic areas rather than focusing on the general population; included vaping as one of the target behaviours which is not included in the Champion, Parmenter, McGowan, Spring, Wafford, Gardner, Thornton, McBride, Barrett, Teesson and Newton (2019) review; and includes research published up until 2022, with no date limits (Champion, Parmenter, McGowan, Spring, Wafford, Gardner, Thornton, McBride, Barrett, Teesson and Newton (2019) included studies published from 2000 to 2017). Second, a team of experts in eHealth prevention interventions for young people contributed to this study by helping review, minimise bias and strengthening the analysis of findings. Third, a thorough, reproducible, and robust search strategy was employed to identify relevant studies. Fourth, this review provides critical information and analysis of important components of effective interventions, which has implications for the design and delivery of future eHealth interventions on this topic.

However, consideration of several limitations in this review is warranted. First, this study did not conduct a systematic search of grey literature, which may have limited the diversity of relevant research studies included in this study as negative results are less likely to be published in peer-reviewed journals. However, grey literature may be prone to high risk of bias (e.g., conflict of interest when the same researcher conducts and evaluates a study) and is not restricted to the same reporting standards of peer-reviewed literature thus may omit important publication information (e.g. publication date, contributors). Second, any interventions framed as treatment rather than prevention were not eligible. As disadvantaged youth are ‘higher risk’, interventions aimed at helping adolescents who were already experiencing unhealthy behaviours (e.g. alcohol use disorder) and insight into alternative methods to reach disadvantaged adolescents may not have been identified in this study’s analysis. Third, the overall risk of bias of included studies was unclear largely owing to authors failing to reference a published protocol, employing self-report as measurement for the outcome, missing outcome data for all participants, and deviations from the intended interventions. Fourth, despite the comprehensive search strategy, no studies targeting vaping met inclusion criteria. However, this is not unexpected considering vaping is a relatively newer behaviour and the limited eHealth trials targeting vaping in the general population. Nevertheless, the potential of vaping exacerbating public health impact among disadvantaged adolescents, posits this is an important area for future research.

3.6.1. Conclusion

To address the disproportionately higher risk of chronic disease burden among disadvantaged adolescents including those of low socioeconomic or geographically remote backgrounds, prevention of lifestyle risk behaviours such as poor diet, alcohol use, tobacco smoking and vaping is critical. Despite evidence supporting the effectiveness of universal eHealth interventions in targeting these behaviours, there are gaps in the literature on whether eHealth interventions adequately serve disadvantaged adolescents. This is the first study to systematically examine and synthesise evidence on eHealth interventions targeting adolescents (aged 10–19 years) from disadvantaged backgrounds in preventing poor diet, alcohol use, tobacco smoking, and vaping. This study revealed that although eHealth interventions can be effective in targeting poor diet and alcohol use among disadvantaged adolescents, limited research in this area has been conducted with only 15 articles assessing 14 interventions included in this study's analysis. Ultimately, this represents a missed opportunity to meaningfully improve chronic disease risk profiles of disadvantaged adolescents, especially considering the growing evidence for the effectiveness of universal eHealth interventions that may delay or prevent the onset of lifestyle risk behaviours. Challenges remain in developing, delivering, and disseminating findings on effective evidence-based programs for the prevention of chronic diseases among disadvantage adolescents. More research on developing and evaluating effective eHealth interventions specific to adolescents from lower socioeconomic and geographically remote contexts is needed.

Chapter 4

Moderating effects of socioeconomic status and geographical location on the Health4Life school-based intervention

Preface

Ensuring that universal, eHealth interventions targeting lifestyle risk behaviours benefit disadvantaged adolescents as equally as their more advantaged peers remains a significant challenge. **Chapter 3** demonstrated that such interventions can be effective in targeting dietary habits, and alcohol consumption, among disadvantaged adolescents. However, the efficacy of universal, school-based, eHealth interventions targeting multiple risk behaviours have reported mixed findings on dietary habits, alcohol, and tobacco behaviours. SES and geographical factors are known to influence lifestyle risk behaviours, yet their influence on the effectiveness of universal, eHealth MHBC interventions is not well understood. This chapter fills this gap by evaluating how SES and geographical location impact the effectiveness of the universal eHealth, school-based intervention, *Health4Life*.

This chapter addresses the third aim of this thesis (Table 1.2):
Examine the influence of SES and geographical location on the efficacy of the universal school-based Health4Life intervention in reducing alcohol and tobacco use, improving dietary habits, knowledge of chronic disease risk behaviours, behavioural intentions and reducing psychological distress.

This moderation analysis is available in Appendix C and has been published as:
Egan, L., Gardner, L. A., Newton, N. C., O'Dean, S., & Champion, K. E. (2024). Moderating effects of socioeconomic status and geographical location on the Health4Life school-based intervention. *Preventive Medicine Reports*. 46. https://doi.org/10.1016/j.pmedr.2024.102855

4.1. Abstract

Objective: This study evaluated the moderating effects of socioeconomic status (SES) and geographical location on the efficacy of an eHealth school-based multiple health behaviour change intervention – *Health4Life* – in targeting alcohol and tobacco use, dietary intake, knowledge, behavioural intentions, and psychological distress over 24-months.

Methods: Data from the *Health4Life* cluster-randomised controlled trial conducted from 2019-2021 in 71 Australian secondary schools were analysed (N=6639; baseline age 11-14yrs). Schools were from metropolitan (89%) and regional (11%) areas, and participants' SES was classified as low (15%), mid (37%), and high (48%) relative to the study population. Primary outcomes included alcohol and tobacco use, and a composite indicator of poor diet. Secondary outcomes were knowledge, behavioural intentions, and psychological distress. Latent growth models assessed moderating effects of SES and geographical location on between-group change over 24-months.

Results: Geographical location moderated the intervention's effect on odds of reporting a poor diet (OR=1.79, 95%CI=1.32-2.43, p< 0.001) and diet-related behavioural intentions (OR=0.71, 95%CI=0.56-0.89, p=0.024) over time. Subset analyses indicated that intervention participants in regional areas had higher odds of reporting a poor diet (OR=1.61, 95%CI=1.13-2.29, p= 0.008), while those in metropolitan areas had higher odds of improving diet-related behavioural intentions (OR=1.13, 95%CI=1.01-1.27, p=0.041), compared to the control group. No other significant moderation effects were observed.

Conclusions: While significant disparities were generally not observed, the geographical differences in intervention effects on diet and diet-related intentions suggest that co-designed and tailored approaches may benefit disadvantaged adolescents to address the disproportionately high rates of lifestyle risk behaviours among these priority populations.

4.2. Background

Sociodemographic inequalities, including socioeconomic status (SES) and geographical location (e.g., urban versus rural areas), significantly contribute to chronic disease burden and are critical determinants of access to resources and health outcomes in society (Australian Institute of Health and Welfare, 2024d; Robards et al., 2018). Adolescents from low SES and

geographically remote contexts are particularly susceptible to this burden (Australian Institute of Health and Welfare, 2021d). The 2018 Australian Burden of Disease Study (Australian Institute of Health and Welfare, 2021d), reports a progressive increase in disability-adjusted life years from affluent to disadvantaged socioeconomic areas, and from major cities to remote areas, with 1.6 and 1.4 times higher rates, respectively. Despite unique differences between adolescents of low SES and geographically remote backgrounds, both groups face similar challenges in achieving health equity. Therefore, the term "disadvantaged" is used to describe these individuals in this context. Disadvantaged adolescent populations encounter various obstacles that impede their access to health, including stigmatisation, lack of social support, limited access to affordable services, and education opportunities (Australian Institute of Health and Welfare, 2024d; Robards et al., 2018).

Disadvantaged adolescent populations, both in Australia and globally, exhibit higher rates of modifiable lifestyle risk behaviours such as poor diet, alcohol use, and tobacco smoking (Australian Institute of Health and Welfare, 2020a; Warren et al., 2017; Wiggins et al., 2020). These may continue into adulthood, increasing the risk of chronic disease and associated burden, especially when they occur together (Krokstad et al., 2017). Adolescence is a critical developmental period (Sawyer et al., 2012), characterised by increased risk-taking tendencies, including experimentation with alcohol and smoking (Degenhardt et al., 2016), and consuming unhealthy foods (Australian Institute of Health and Welfare, 2018). Clustering or the co-occurrence of these behaviours in adolescence is common (Uddin et al., 2020), and linked with adverse outcomes, including obesity (Bardach et al., 2023), reduced quality of life (Hoare, Crooks, et al., 2019) and mental ill-health (Champion et al., 2018; Gardner, Champion, et al., 2022). Indeed, research has reported that adolescents with a history of early-life low SES often face co-occurring adverse health and educational challenges (Villadsen et al., 2023). Therefore, prioritising prevention during adolescence is crucial for promoting healthy behaviours, mitigating the risk of chronic diseases in adulthood, and addressing health disparities experienced by this vulnerable population.
Electronic health (eHealth) interventions hold promise in benefiting disadvantaged adolescents by providing accessible and low-cost resources that can increase student engagement and implementation fidelity (Champion, Parmenter, McGowan, Spring, Wafford, Gardner, Thornton, McBride, Barrett, Teesson, & Newton, 2019). Multiple systematic reviews have demonstrated the efficacy of universal eHealth interventions in preventing and addressing poor diet (Kemp et al., 2021), tobacco smoking (Taylor et al., 2017), and/or

reducing alcohol use (Kazemi et al., 2021) among adolescents. Although, a recent meta-analysis of universal school-based prevention eHealth interventions targeting multiple health risk behaviours found them ineffective in preventing alcohol consumption or smoking and reducing fat, sugar-sweetened beverages (SSB), or snack consumption (Champion, Parmenter, McGowan, Spring, Wafford, Gardner, Thornton, McBride, Barrett, Teesson, & Newton, 2019). The review recommended focusing on skill development and social influence and competence theories for improved outcomes. Despite these mixed findings, evidence supports the effectiveness of universal eHealth interventions in preventing or delaying the onset of modifiable health risk behaviours (Newton et al., 2017; Qiu et al., 2022). However, their effectiveness for disadvantaged adolescents is not as well-known, with only one systematic review published on eHealth prevention interventions targeting poor diet, alcohol use, and tobacco smoking among disadvantaged adolescents (Egan et al., 2023). The review indicated that eHealth interventions can be effective in targeting poor diet (e.g., decreasing SSB consumption) and alcohol use (e.g., reducing binge drinking at 1-month follow-up among intervention completers) among disadvantaged adolescents. However, it also acknowledged limitations due to the scarcity of published studies on this topic, with only 15 publications assessing 14 interventions eligible for inclusion.

The Australian *Health4Life* initiative is an innovative eHealth school-based intervention targeting multiple lifestyle risk behaviours among adolescents: alcohol use, tobacco smoking, poor diet, physical inactivity, poor sleep, and sedentary recreational screen time (Teesson et al., 2020). Co-designed with young people, *Health4Life* incorporates personalised feedback and is grounded in social influence, social cognitive, and self-determination theories (Champion et al., 2020). Results from a cluster randomised controlled trial (RCT) of *Health4Life* found significant effects on reducing behavioural intentions to try alcohol and tobacco at post-intervention (O'Dean et al., 2024), improving mental health outcomes (Smout, Champion, O'Dean, Gardner, et al., 2024) and knowledge about chronic disease risk factors over 24-months (Champion et al., 2023). However, the RCT reported no significant intervention effects on modifying alcohol or tobacco use, poor diet, physical inactivity, poor sleep or screen time across the entire sample (Champion et al., 2023). Despite *Health4Life*'s positive reception by students (74.8%) and teachers (84%), and the significant improvement in knowledge, this did not translate into behaviour change. *Health4Life* baseline data (n=6639 11-14 year-olds across NSW, WA, and QLD) revealed socio-demographic disparities in diet, alcohol, and tobacco use (Champion et al., 2021). For instance, students from regional areas

were more likely to use alcohol than those from major cities, and students with lower SES were more likely to use alcohol and tobacco and have poorer diets than their peers with middle to upper SES. Given these disparities we expect that *Health4Life*'s efficacy may differ in these subgroups, potentially due to distinct challenges influencing their health behaviours differently. Tailored approaches may be needed, however, evidence is currently unclear.

Nonetheless, considering the significant influence of SES and geographical factors on health-related behaviours, it is essential to examine their impact on the efficacy of interventions such as *Health4Life*. This study aims to evaluate the moderating effects of SES and geographical location on the efficacy of the *Health4Life* intervention in reducing alcohol and tobacco use, improving dietary intake, knowledge of chronic disease risk behaviours, behavioural intentions, and reducing psychological distress.

4.3. Methods

4.3.1. Participants & Procedure

The current study uses baseline to 24-month follow-up data from the *Health4Life* study (Teesson et al., 2020), a cluster randomised controlled trial in 71 secondary schools across Australia. Recruitment details have been reported previously (Champion et al., 2023). Briefly, 71 schools were block randomised (1:1) by a biostatistician independent to recruitment to either the *Health4Life* intervention (N=36) or active control group (usual health education; N=35). Randomisation was stratified by school location (state/region) and gender composition (coeducational, mostly female [>60%], or mostly male [>60%]). It was not possible to blind students, teachers, and researchers to group assignment, as is standard with school-based interventions.

The study's parental consent approaches varied based on the ethical requirements of the schools involved. While 40 schools provided an opt-out option, 31 required active written and oral consent (i.e., opt-in). All students provided active written consent to participate in the study.

The intervention group received *Health4Life*, consisting of six web-based modules delivered during health education lessons, ideally once per week. Based on social influence, social cognitive, and self-determination theories to prevent multiple lifestyle risk behaviours, key

behaviour change techniques are integrated into 20-minute interactive cartoon storylines with characters similar in age to grade 7 students (Champion et al., 2020). These cartoons, the core component of *Health4Life*, impart evidence-based information about health and social consequences of poor diet, alcohol use, tobacco smoking, physical inactivity, poor sleep, and sedentary recreational screen time, while also promoting resistance skills, normative education, and autonomous motivation. Students complete short online quizzes after each module, and factsheets for teachers and students are available to reinforce the content. *Health4Life* is supplemented by web-based tailored feedback on adherence to national health guidelines, optional online or teacher-led activities, and a smartphone app designed to encourage self-monitoring of behaviours and goal setting. Control schools delivered usual health education, approximately once a week.

Participants completed self-report online surveys during class at four time points: baseline (2019); immediately following the intervention (2019); 12-months after baseline (2020); 24-months after baseline (2021). To maximise retention, two participants from each school were randomly allocated a AUD$100 gift voucher for completing the surveys.

This trial was prospectively registered with the Australian New Zealand Clinical Trials Registry (ACTRN12619000431123) and adheres to CONSORT guidelines.

4.3.2. Measures

4.3.2.1. Sociodemographic factors

Students provided self-reported information on gender, age, SES and geographical location. SES was categorised into lower, middle and upper groups based on Family Affluence III ridit scores (Elgar et al., 2017), and geographical location was classified as metropolitan or regional based on the Australian Statistical Geography Standard Remoteness Structure (Australian Bureau of Statistics, 2023).

4.3.2.2. Primary outcomes

Diet: The Student Physical Activity and Nutrition Survey (SPANS) measured the consumption of SSBs, fruit, vegetables, and discretionary foods (Hardy et al., 2016). A composite indicator of poor diet was then calculated. Individuals were classified as having a poor diet if they reported high SSB consumption (5-6 cups/week or 1 or more cups/day of SSB) or met two or more of the following conditions: consuming fewer than two servings of

fruit per day, consuming fewer than five servings of vegetables per day, or consuming more than one serving of discretionary food items per day. The cut-offs for fruit and vegetable intake were based on the Australian Dietary Guidelines (National Health and Medical Research Council, 2013), while nutritionists and health recommendations guided SSB and discretionary food variables.

Alcohol: A single item measured participants' consumption of a full standard drink by asking participants, "Have you had a full standard alcoholic drink in the past 6 months?" (0= No, 1= Yes). To facilitate participants' responses, they were shown a pictorial chart displaying the standard drink quantities of various types of alcoholic beverages and sizes.

Tobacco: A single item measure from the Youth Risk Behaviour Survey assessed tobacco use with participants asked, "In the past 6 months, have you tried cigarette smoking, even one or two puffs?" (0= No, 1=Yes) (Brener et al., 2013).

4.3.2.3. Secondary outcomes

Knowledge: A 20-item scale assessed participants' knowledge of *Health4Life* study content, including awareness of chronic disease risk factors, alcohol guidelines, prevalence of alcohol and tobacco use among young Australians, and the impact of six lifestyle risk behaviours on physical and mental health. Items were presented as "True", "False", "Don't Know" statements, and scores were totalled to produce an overall knowledge score.

Behavioural Intentions: Participants self-reported their intentions to participate in or modify behaviours relating to poor diet, alcohol and tobacco use. Alcohol intentions were evaluated using established measures (Newton et al., 2012), with items for tobacco and poor diet (specifically SSBs including energy drinks, soft drinks, sports drinks, or cordial) adapted from these measures. Participants rated their likelihood of trying alcohol and tobacco on a scale from 0 (very unlikely) to 4 (very likely). For SSBs, they indicated their intention to replace them with water on a scale from 0 (not at all true of me) to 3 (very true of me) on all or most days over the next three months. Responses were then converted into binary variables for subsequent analyses in this study. Scores of 0-2 for alcohol and tobacco questions indicated no intention to engage in alcohol use or tobacco smoking, while scores of 3-4 indicated an intention to do so. Regarding SSBs, responses of 0-1 were recoded as no

intention to replace SSB consumption with water, while responses of 2-3 indicated an intention to make the substitution.

Psychological Distress: The Kessler 6 (K6) scale, a widely used and validated measure, assessed psychological distress among adolescents by evaluating six symptoms experienced by individuals over the past four weeks (Furukawa et al., 2003; Mewton et al., 2016). These symptoms include feeling nervous, hopeless, or restless. Participants rated each symptom on a 5-point Likert scale ranging from "none of the time" to "all of the time". Scores were totalled to create a composite score, with higher scores indicating greater psychological distress.

4.3.3. Statistical Analysis

A post-hoc exploratory moderation analysis was chosen for the current study. Latent growth curve models (LGMs) in Mplus (v 8.4. (Muthén & Muthén, 2017)) were used to evaluate the moderating effects of SES and geographical location on primary and secondary outcomes over 24-month post baseline assessments. Various LGMs were used based on the distribution of the outcome variables, including binary, continuous, or ordinal models. To determine the optimal time structure and interpretation of slope estimates for each outcome, we explored various specifications of time scores, including linear, quadratic, and freely estimated, on unconditional LGMs. We compared model fit using Akaike information criterion (AIC), Bayesian information criterion (BIC), and sample-size adjusted BIC. Further details regarding model interpretation are provided in Appendix 3.2. The analysis applied the full-information maximum likelihood (FIML) estimation within the LGMs, aligning with intention-to-treat principles to handle missing data. FIML uses all available information when estimating parameters, and it is recognised for its superiority over conventional methods within the context of LGMs (Schafer & Graham, 2002). To account for the effect of testing multiple outcomes, the Benjamini-Hochberg approach, also known as the false discovery rate control, was applied (Benjamini & Hochberg, 1995). Unlike more conservative methods such as the Bonferroni correction, the Benjamini-Hochberg approach offers increased power to identify true associations when testing multiple outcomes. To interpret statistically significant interactions ($p<0.05$), we conducted subset analyses that investigated the main effects of intervention within each level of the moderating variables (i.e., SES or geographical location).

4.3.4. Ethics

The *Health4Life* study was approved by the University of Sydney (2018/882), the University of Queensland (2019000037), Curtin University (HRE2019–0083), and ethics committees in the relevant school sectors.

4.4. Results

4.4.1. Descriptive Statistics

A total of 6,639 students from 71 schools participated in the baseline survey, constituting the analysed sample for this study. The students had a mean age of 12.7 years (SD 0.50; range 11-14 years). In terms of gender, 49.9% (n = 3,311) identified as male, 48.3% (n = 3,204) identified as female, 0.5% (n = 30) identified as non-binary or gender fluid, 0.1% (n = 9) had a different gender identity, and 1.0% (n = 69) preferred not to disclose their gender identity. The sample included students from diverse socioeconomic backgrounds, with 15% classified as low SES, 37% as mid SES, and 48% as high SES. Furthermore, the sample represented both metropolitan and regional areas, with 89% residing in metropolitan areas and 11% in regional areas (Table 4.1). Retention rates and the number of students who completed follow-up surveys are reported in Appendix 3.1.

Table 4.1. Baseline (2019) sample characteristics of adolescents participating in the Australian Health4Life Study.

Characteristic											
	Socioeconomic status n (%)						**Geographical location n (%)**				
	Low SES: Control	Low SES: Health4Life	Mid SES: Control	Mid SES: Health4Life	High SES: Control	High SES: Health4Life	Metropolitan: Control	Metropolitan: Health4Life	Regional: Control	Regional: Health4Life	
	351 (5.3)	558 (8.4)	1005 (15.1)	1204 (18.1)	1336 (20.1)	1560 (23.5)	2650 (39.9)	3303 (49.8)	380 (5.7)	306 (4.6)	**Total**
Age (mean, SD)	12.66 (0.49)	12.65 (0.51)	12.63 (0.51)	12.67 (0.49)	12.64 (0.51)	12.66 (0.49)	12.64 (0.51)	12.65 (0.50)	12.64 (0.49)	12.79 (0.49)	12.7 years (0.50)
Gender n (%)											
Male	178 (50.9)	330 (59.1)	470 (47.0)	659 (54.7)	612 (45.8)	702 (45.0)	1239 (46.9)	1671 (50.7)	207 (54.6)	194 (63.6)	3,311 (49.9)
Female	164 (46.9)	217 (38.9)	510 (50.9)	520 (43.2)	705 (52.8)	844 (54.1)	1354 (51.2)	1574 (47.8)	167 (44.1)	108 (35.4)	3,204 (48.3)
Non-binary or gender fluid	3 (0.9)	5 (0.9)	8 (0.8)	4 (0.3)	3 (0.2)	4 (0.3)	15 (0.6)	14 (0.4)	1 (0.3)	0 (0.0)	30 (0.5)
Different gender identity	0 (0.0)	1 (0.2)	1 (0.1)	3 (0.2)	2 (0.1)	1 (0.1)	4 (0.2)	4 (0.1)	0 (0.0)	1 (0.3)	9 (0.1)
Preferred not to disclose	5 (1.4)	5 (0.9)	12 (1.2)	18 (1.5)	14 (1.0)	9 (0.6)	30 (1.1)	33 (1.0)	4 (1.1)	2 (0.7)	69 (1.0)
State n (% of participants)											
New South Wales	220 (62.7)	355 (63.6)	487 (48.5)	645 (53.6)	639 (47.8)	929 (59.6)	1392 (52.5)	1808 (54.7)	103 (27.1)	233 (76.1)	37 schools (53.2)
Queensland	56 (16.0)	141 (25.3)	214 (21.3)	412 (34.2)	332 (24.9)	493 (31.6)	655 (24.7)	1133 (34.3)	0 (0.0)	0 (0.0)	18 schools (26.9)
Western Australia	75 (21.4)	62 (11.1)	304 (30.2)	147 (12.2)	365 (27.3)	138 (8.8)	603 (22.8)	362 (11.0)	277 (72.9)	73 (23.9)	16 schools (19.8)

4.4.2. Moderation Effects in Latent Growth Curve Models

Conditional growth curve models

There was a significant moderating effect of geographical location on intervention effectiveness for poor diet (OR = 1.79, 95% CI = 1.32-2.43, p < 0.001) (Figure 4.1). Subset analyses revealed for those who resided regionally, there was greater growth in the odds of having a poor diet in the intervention group compared to the control (OR = 1.61, 95% CI = 1.13-2.29, p = 0.008), and little evidence of a difference between groups for those residing in metropolitan cities (OR = 0.99, 95% CI = 0.86-1.14, p = 0.915) (Appendix 3.6). There was little evidence supporting a moderation effect of SES on intervention effectiveness for poor diet (OR = 0.99, 95% CI = 0.87-1.13, p = 0.856) (Table 4.3). In addition, geographical location significantly moderated the intervention effectiveness in promoting behavioural intentions to swap SSB for water (OR = 0.71, 95% CI = 0.56-0.89, p = 0.024 (Figure 4.2)). Subset analyses revealed for those who resided in metropolitan cities, there was a significantly greater increase in the odds of intending to swap SSB for water in the intervention group compared to the control (OR = 1.13, 95% CI = 1.01-1.27, p = 0.041), and little evidence of a difference between groups for those who resided regionally (OR = 0.97, 95% CI = 0.72-1.32, p = 0.857). There was little evidence of a moderation effect of SES on the intervention effectiveness in targeting diet-related behavioural intentions at 24-months (OR = 1.03, 95% CI = 0.92-1.15, p = 0.685).

Figure 4.1. Predicted and raw proportion of poor diet among metropolitan and regional participants in the Australian Health4Life Study. Solid lines are raw values and dotted lines are predicted values.

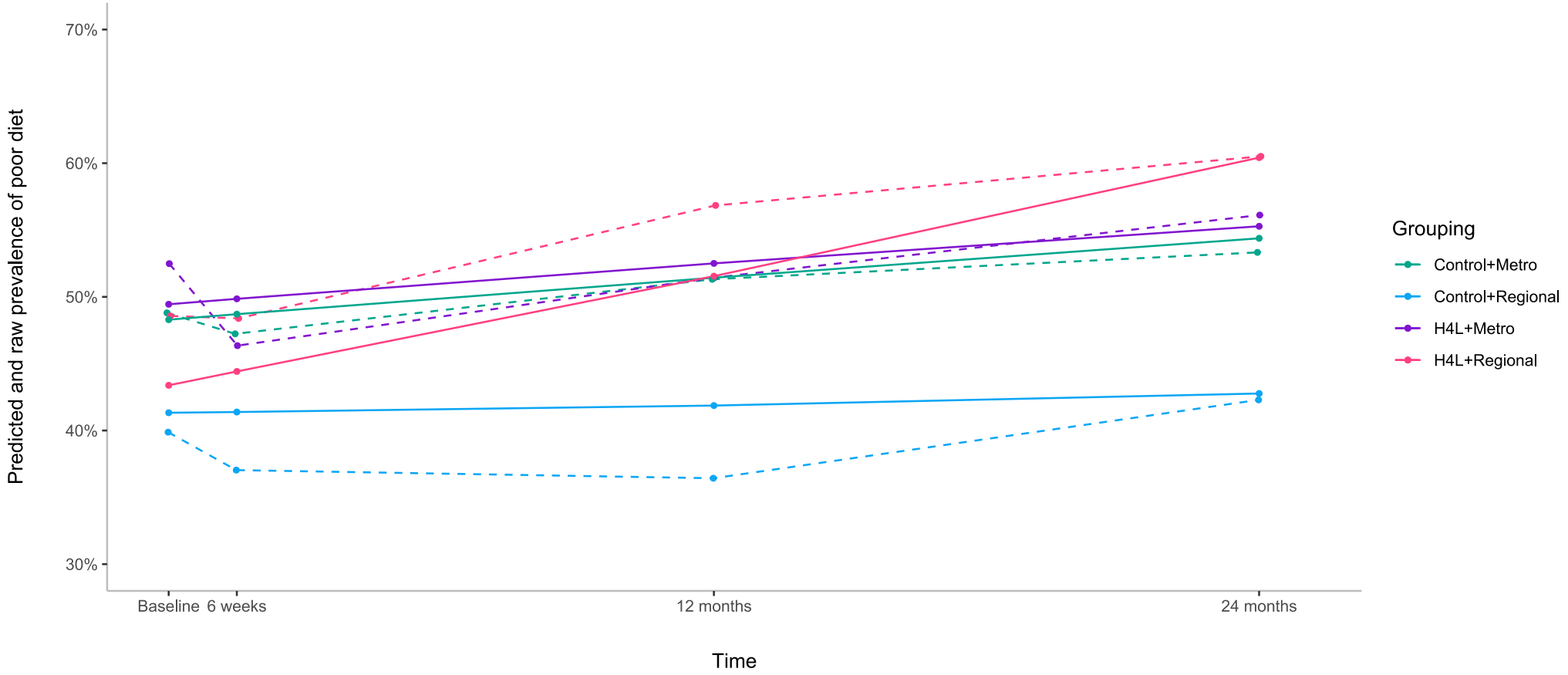
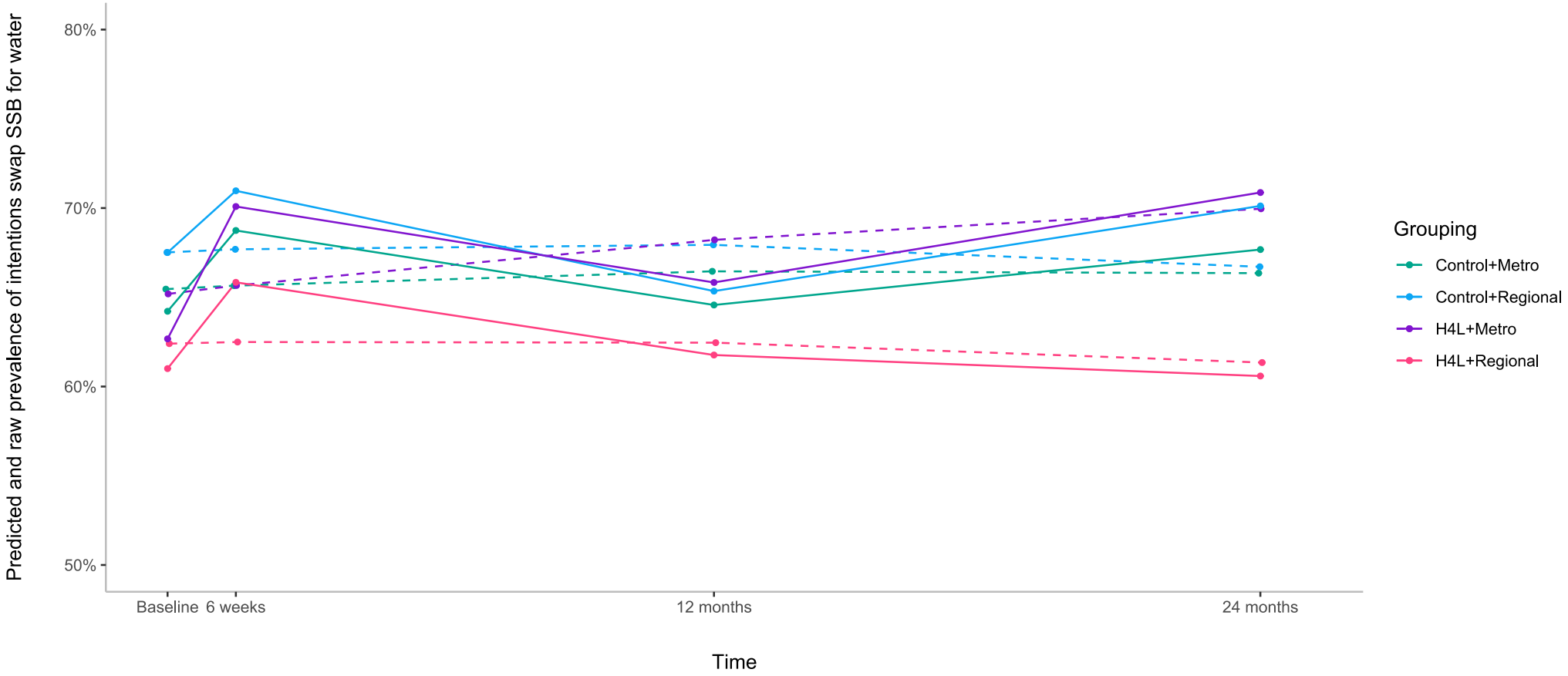


Figure 4.2. Predicted and raw proportion of intentions to swap SSB for water among metropolitan and regional participants in the Australian Health4Life Study. Solid lines are raw values and dotted lines are predicted values



There was little evidence for a moderation effect of SES or geographical location on the average change in odds of alcohol (OR = 0.81, 95% CI = 0.52-1.25, p = 0.489) or tobacco use (OR = 0.60, 95% CI = 0.37-0.95, p = 0.124) in the past 6-months, and alcohol-related (OR = 0.98, 95% CI = 0.81-1.19, p = 0.856) and tobacco-related behavioural intentions (OR = 0.86, 95% CI = 0.68-1.08, p = 0.457) over the 24-months. Likewise, over the 24-month duration there were no moderation effects of SES on the mean knowledge scores of chronic disease risk factors (0.08, SE = 0.09, p = 0.502) or psychological distress (-0.13, SE = 0.13, p = 0.489), nor of geographical location on the mean knowledge scores of chronic disease risk factors (-0.42, SE = 0.26, p – 0.365) or psychological distress (0.33, SE = 0.36, p = 0.495) (Table 4.2 & Table 4.3).

Table 4.2

Summary of logistic latent growth parameters, CIs and SE investigating the effects of SES on moderating the odds of study outcomes from the Australian Health4Life Study.

	Intercept		Slope	
Logistic latent growth model				
	OR (CI)	p	OR (CI)	p
Poor diet	1.13 (0.88, 1.47)	0.336	0.99 (0.87, 1.13)	0.856
Alcohol	0.86 (0.52, 1.42)	0.554	0.81 (0.52, 1.25)	0.489
Tobacco	0.78 (0.43, 1.44)	0.440	0.60 (0.37, 0.95)	0.124
Diet intentions	0.97 (0.81, 1.16)	0.743	1.03 (0.92, 1.15)	0.685
Alcohol intentions	0.62 (0.39, 0.99)	0.046	0.98 (0.81, 1.19)	0.856
Tobacco intentions	0.88 (0.57, 1.38)	0.587	0.86 (0.68, 1.08)	0.457
Continuous latent growth model				
	b(SE)	p	b(SE)	p
Knowledge	-0.43(0.19)	0.022	0.08(0.09)	0.502
Psychological Distress	-0.11(0.25)	0.671	-0.13(0.13)	0.489

Table 4.3

Summary of logistic latent growth parameters, CIs and SE investigating the effects of Metropolitan-Regional on moderating the odds of study outcomes from the Australian Health4Life Study.

	Intercept		Slope	
Logistic latent growth model				
	OR (CI)	p	OR (CI)	p
Poor diet	1.13 (0.87, 1.46)	0.369	1.79 (1.32, 2.43)	<0.001
Alcohol	0.84 (0.51, 1.39)	0.501	2.53 (0.44, 14.48)	0.489
Tobacco	0.80 (0.43, 1.48)	0.473	5.92 (1.45, 24.18)	0.069
Diet intentions	0.96 (1.15, 1.27)	0.666	0.71 (0.56, 0.89)	0.024
Alcohol intentions	0.60 (0.38, 0.97)	0.037	0.76 (0.44, 1.33)	0.489
Tobacco intentions	0.83 (0.55, 1.27)	0.392	2.01 (0.75, 5.38)	0.437
Continuous latent growth model				
	b(SE)	p	b(SE)	p
Knowledge	-0.38(0.19)	0.046	-0.42(0.26)	0.365
Psychological Distress	-0.10(0.25)	0.679	0.33(0.36)	0.495

4.5. Discussion

This is the first study to examine the moderating effects of SES and geographical location on the effectiveness of the *Health4Life* intervention in reducing alcohol and tobacco use, improving dietary intake, knowledge of chronic disease risk behaviours and behavioural intentions, and reducing psychological distress over 24-months. Overall, the study found little evidence for a moderation effect, with the exception of diet-related outcomes by geographical location. This is consistent with the primary outcomes of the *Health4Life* RCT, which revealed no significant intervention effects on alcohol use, tobacco smoking and poor diet across the entire sample (Champion et al., 2023).

Importantly, *Health4Life* draws from social influence, social cognitive, and self-determination theories (Champion et al., 2020), which aligns with recommendations for eHealth interventions among adolescents of low SES or of geographically remote backgrounds (Egan et al., 2023). However, *Health4Life* was not specifically designed to

address the unique experiences of disadvantaged adolescents, who often encounter structural barriers including limited access to resources, support, and economic constraints (Australian Institute of Health and Welfare, 2024d; Robards et al., 2018). These barriers create a more challenging environment for adopting and maintaining positive health behaviours compared to their more advantaged peers. For instance, healthy food options are less affordable and less available in low SES and regional areas (Love et al., 2018), and there may be lower levels of social support (Gautam et al., 2023), both of which are crucial for sustaining healthy behaviours. Moreover, *Health4Life*'s foundational principles assume a level of autonomy and resource availability that disadvantaged adolescents may not have e.g. financial constraints limiting control over health choices. While the theoretical underpinnings of *Health4Life* are sound, their practical application may be undermined if positive health behaviours are not modelled or encouraged (Bandura, 2004) which may be the reality in disadvantaged adolescents' environments. Together this may explain why *Health4Life* was limited in effectively modifying alcohol and tobacco use, knowledge, alcohol- and tobacco-related behavioural intentions, and psychological distress in this population.

The present findings suggest that, generally, outcomes were not influenced by SES and geographical location. Instead, the intervention's effects may be attributed to other underlying mechanisms. For instance, despite the myriad of challenges linked to varying SES and regional contexts, *Health4Life* maintained a positive impact on adolescents' knowledge of chronic disease risk behaviours, potentially due to other factors such as personal motivation or learning styles. The absence of significant moderation effects on other outcomes, including alcohol and tobacco use, suggests that *Health4Life*'s impact on these behaviours may vary depending on individual characteristics and contextual factors, such as family dynamics and social support that could be targeted through tailored interventions. For example, interventions may target the home environment by involving parents. Additionally, including peers in the intervention process may help create a supportive network. These refinements may benefit *Health4Life*'s efficacy for all participants, and to further enhance *Health4Life*'s efficacy for low SES and regional populations, addressing structural barriers and other social determinants that could influence health behaviours is essential. Given disadvantaged adolescents exhibit higher rates of these lifestyle risk behaviours than their more advantaged peers (Australian Institute of Health and Welfare, 2020a; Warren et al., 2017; Wiggins et al., 2020), this tailoring may lead to more significant and equitable health improvements among these populations. This highlights the importance of co-design and

tailoring interventions to disadvantaged populations (Egan et al., 2023). Emerging interventions such as Just-in-Time-Adaptation, which use real-time data to provide personalised support through digital platforms, may also be beneficial for this population as they are easily accessible, individually tailored and practical (Partridge & Redfern, 2018).

Diet-related outcomes are an exception to the null findings. *Health4Life* improved diet-related behavioural intentions for those residing in metropolitan areas, but not regional areas. However, this did not translate into dietary behaviour change, contrasting with a separate study that improved both behavioural intentions and fruit and vegetable consumption (Kothe et al., 2012). This discrepancy challenges the Theory of Planned Behaviour, which posits that intention is a proximal determinant of behaviour (Bosnjak et al., 2020). External factors, such as peer pressure influencing dietary choices (Ragelienė & Grønhøj, 2020), coupled with socio-cultural influences (e.g., prevalent advertising of unhealthy foods in metropolitan areas (Richmond et al., 2020; Sainsbury et al., 2017)) may have counteracted the positive intentions fostered by the intervention, making it more challenging for these adolescents to adopt healthier eating habits. Future interventions should focus on modifying behavioural intentions and strategies to mitigate these external influences.

Unexpectedly, regional participants in the intervention group had greater growth in the odds of having a poor diet compared to controls. This disparity may be due to the health education provided in regional control groups placing a stronger emphasis on dietary education than *Health4Life*. While *Health4Life*, given its multiple behaviour change framework, provided an equivalent of one to two 15-minute lessons on diet, teacher-reported data revealed that most regional control schools dedicated a minimum of one to two 40-minute lessons solely to diet education, and some delivered up to six lessons. Within the Australian curriculum, students learn about making healthy and safe food choices, including food-serving recommendations from *The Australian Guide to Healthy Eating* and practical advice on choosing healthy options from the school canteen (Australian Curriculum Assessment and Reporting Authority, n.d). The control schools' focused approach, coupled with greater frequency and depth on diet education than *Health4Life*, may have equipped students with more knowledge and strategies for making healthier food choices. This suggests *Health4Life* should incorporate a more intensive dietary education component, especially in regional areas. Although it is worth noting that data were not collected on other characteristics in the control and Health4Life schools, such as policies (canteen, nutrition, other health promotion policies)

and food environments, which may have affected diet outcomes. Nevertheless, as previously mentioned, *Health4Life* was not specifically designed for disadvantaged adolescents, and regional areas may have unique challenges that the intervention did not adequately address. For instance, control schools may have better addressed the social and environmental context, including lower affordability or availability of healthy food, to ensure health-promoting messages were relevant, practical, and accessible within the local context. To overcome this, future studies could adopt matched sampling methods to ensure the control and intervention schools do not drastically differ in the amount of health education they deliver (Chondros et al., 2021; Hemming & Taljaard, 2023). A process evaluation of *Health4Life* in regional schools is also needed to understand the implementation context and identify any other factors that may have contributed to this unintended effect. Ultimately, the conflicting diet-related findings observed in this study highlight the need for further research to replicate and explore potential explanations, informing improvements in future interventions targeting dietary behaviours among disadvantaged adolescents.

4.5.1. Strengths & Limitations

This study has several strengths and limitations. Firstly, the use of the composite diet risk score provides an overall perspective on diet, however, may overlook specific dietary nuances. Although the fruit and vegetable variables align with official government guidelines (National Health and Medical Research Council, 2013), the lack of guidelines for SSB and junk food variables required input from a multidisciplinary team, including nutritionists, and following health recommendations to determine the “at-risk” cutoffs for these variables. Additionally, the item assessing diet-related intentions focused solely on intentions to swap SSB for water. Although SSB is one relevant indicator of poor diet (National Health and Medical Research Council, 2013), future studies should adopt more comprehensive measures. The use of the Family Affluence Scale III as a proxy measure for SES, while practical, simplifies evaluation by relying on a limited number of indicators, such as overseas holidays (Torsheim et al., 2016). This approach may overlook the multidimensional aspects of SES, including income and education. Furthermore, self-reported information introduces potential bias, as respondents may interpret scale items differently. Acknowledging limitations imposed by the COVID-19 pandemic is also essential. In Australia, adolescents in high and low lockdown states experienced increased negative emotions (Meyer et al., 2023), poorer mental health, limited physical activity and increased screen time (Gardner, Debenham, et al.,

2022; Goldfeld et al., 2022). Similar patterns were observed overseas (Lawrance et al., 2022). Although *Health4Life* was implemented in 2019, the follow-up assessments coincided with the pandemic, possibly influencing participants' response to *Health4Life* and their ability to apply acquired knowledge and skills.

The study sample included students from independent, public, and Catholic secondary schools across three Australian states, contributing to its diversity. However, most students were born in Australia, of middle or upper SES, and residing in major cities (Champion et al., 2021), potentially limiting generalisability. Moreover, including only inner and outer regional students, with no remote schools, impacts understanding whether *Health4Life* had any differential effects by diverse regional groups. Finally, geographical moderation analysis results for alcohol and tobacco outcomes require cautious interpretation due to wide confidence intervals, primarily attributed to low cell counts and low prevalence of use.

Notwithstanding these limitations, a key strength of the *Health4Life* study is its rigorous cluster RCT design and large sample size, making it one of the most extensive school-based studies of its nature. The meticulous development and implementation of *Health4Life* involved close collaboration with end-users (Champion et al., 2023), ensuring the intervention's relevance and engagement among students and teachers. Moreover, *Health4Life*'s favourable acceptability within a school setting enhances its potential for wider applicability and impact. Future work is underway to refine *Health4Life*'s content to better address the specific needs of low SES and geographically remote adolescents.

4.5.2. Conclusion

This study offers valuable insights into how SES and geographical factors interacted with the *Health4Life* intervention's effectiveness in targeting alcohol and tobacco use, dietary intake, knowledge, behavioural intentions, and psychological distress. Generally, outcomes were not influenced by SES and geographical location. However, the exception to this pattern is in diet-related outcomes, with varying effects on poor diet and diet-related behavioural intentions based on participants' geographical location, underscoring the importance of considering regional differences in intervention design and implementation. Co-designing and tailoring interventions is essential to address disparities in chronic disease risk behaviours among disadvantaged adolescent populations. Future research should consider the impact of

SES and geographical factors in intervention design and implementation to optimise outcomes and promote health equity.

Chapter 5

Process evaluation of the digital Health4Life intervention among a sample of disadvantaged adolescents and teachers

Preface

There is limited evidence regarding the facilitators and barriers to disadvantaged adolescents' participation in digital, school-based interventions targeting lifestyle risk behaviours. Understanding the implementation processes and the contextual factors that affect participation is essential for ensuring these interventions are effective among different populations. As identified in **Chapter 3**, while process evaluations of eHealth interventions targeting lifestyle risk behaviours exist, few focus on disadvantaged adolescents, and even fewer include data from both students (the end-users) and teachers (those supporting the implementation). Given that SES and geographic factors influence health behaviours, it is crucial to assess how these factors impact the implementation and outcomes of eHealth school-based interventions to better meet the needs of disadvantaged adolescents. This study elucidates explanations for the findings of **Chapter 4** by conducting a process evaluation of the *Health4Life* intervention among a subsample of 214 disadvantaged students and 16 teachers.

This chapter addresses the fourth aim of this thesis (Table 1.2):
Investigate the implementation and relevance of the universal school-based Health4Life intervention among disadvantaged adolescents in Australia.

This process evaluation is available in Appendix D and has been published as:
Egan, L., Gardner, L. A., Newton, N. C., & Champion, K. E. (2024). Process evaluation of the digital Health4Life intervention among a sample of disadvantaged adolescents and teachers. *Health Promotion International*. 39(6). https://doi.org/10.1093/heapro/daae170

5.1. Abstract

Disadvantaged adolescents, including those from lower socioeconomic status (SES) or geographically remote backgrounds, engage in higher rates of risk behaviours including poor diet, alcohol and tobacco use. While digital interventions targeting lifestyle risk behaviours show potential, few studies have focused on their implementation and relevance for this population. This study conducted a process evaluation of 'Health4Life', a universal school-based digital program targeting multiple behaviours, among a sample of disadvantaged adolescents. Participants were from six schools classified as low SES (Index of Community Socio-educational Advantage percentile score =<25%), and/or regional using the Australian Statistical Geography Standard. Self-reported student (n=214) and teacher evaluations (n=16) assessed Health4Life's acceptability, with qualitative questions capturing areas for improvement. Teacher-reported implementation data (n=16) measured intervention fidelity and feasibility. Quantitative data were analysed using descriptive statistics and open-ended responses were thematically analysed. Compared to the entire sample, this subset of students evaluated Health4Life less favourably (66% versus 75%), with fewer enjoying the stories (63% versus 75%) and planning to use the skills and information (60% versus 70%). Teacher evaluations were mostly positive and aligned closely with the entire sample. Fidelity data also indicated comparable levels of student engagement (~92% versus ~85%). Key themes for refinement included improving content relevance and technical execution to better resonate with disadvantaged adolescents. While teacher evaluations suggest Health4Life is a valuable program in low SES or regional contexts, students' lower ratings indicate refinements are needed. Identified areas for improvement will guide co-designing the program's adaptation to improve effectiveness and relevance for disadvantaged adolescents.

5.2. Background

Research increasingly demonstrates that social determinants, including the contexts in which a person is born, raised, and lives, as well as their occupation and access to health resources are linked to health outcomes (Commission on Social Determinants of Health, 2008; Flavel et al., 2024; Spencer et al., 2019; Russell M Viner et al., 2012) including chronic diseases such as cancer, substance use disorders and mental ill-health (Marmot & Bell, 2019; Massouh et al., 2023). Disadvantaged adolescents, including those of low socioeconomic status (SES) or living in geographically remote areas, are particularly vulnerable to experiencing greater chronic disease burden and tend to report higher rates of modifiable lifestyle risk behaviours,

including poor diet, and alcohol and tobacco use, than their more advantaged peers (Australian Institute of Health and Welfare, 2020a; Gautam et al., 2023). These behaviours are among the highest contributors to chronic disease morbidity and mortality in adulthood and often manifest during adolescence (Akseer et al., 2020). Thus, preventing disadvantaged adolescents' engagement in these modifiable lifestyle risk behaviours is a public health priority and is critical for safeguarding their health and reducing healthcare burden and health inequities.

To achieve this, surmounting social, structural and economical barriers to access and participation in preventive interventions for disadvantaged adolescents is critical (Alliott et al., 2022). School-based digital interventions, delivered through various platforms including computers, internet, mobiles, or telephones, leverage adolescents frequent use of technology to reach them in a space they are already engaged with (Australian Bureau of Statistics, 2016-17; Patton et al., 2016; Vogels et al., 2022). Compared to traditional face-to-face interventions, digital interventions overcome socioeconomic and geographic barriers to access by offering accessible and convenient access to evidence-based content, with increased cost-effectiveness and potential for enhanced engagement and fidelity (Newton et al., 2017). Despite evidence supporting their effectiveness among the general population (Champion, Parmenter, McGowan, Spring, Wafford, Gardner, Thornton, McBride, Barrett, Teesson, et al., 2019; Alison Hutton et al., 2020; Newton et al., 2022), it is essential to tailor digital interventions to the needs and skills of disadvantaged adolescents to promote effective engagement (Yardley et al., 2016). This is crucial for facilitating disadvantaged adolescents' participation, particularly as they already face unique challenges to health including stigma (Robards et al., 2018), less social support (WHO, 2016), and poorer access to health services (Australian Institute of Health and Welfare, 2019a). Thus, understanding how SES and geographical location influence the implementation and effectiveness of such interventions is crucial. Conducting process evaluations can be highly beneficial in this regard, as they aim to understand implementation and contextual factors that may act as facilitators and/or barriers to participation and influence intervention outcomes across different settings (Moore et al., 2015).

Although digital interventions should ideally be received similarly (i.e. in terms of perceived satisfaction and use) across different socioeconomic groups and geographical locations (e.g. metropolitan and regional areas), disadvantaged adolescents may not benefit as much from

interventions as their more advantaged counterparts due to the aforementioned barriers. Thus, process evaluations are critical for determining whether interventions meet the needs of disadvantaged adolescents, and for identifying challenges and areas requiring refinement to optimise intervention acceptability and efficacy (Ellard & Parsons, 2010). However, few process evaluations of digital interventions targeting lifestyle risk behaviours among disadvantaged adolescents have been conducted. For instance, in a recent systematic review of digital interventions targeting diet, alcohol and tobacco use among disadvantaged adolescents, only eight of the fourteen studies included reported process evaluation outcomes (Egan et al., 2023). Although most studies reported high participant satisfaction with the interventions, the feasibility, fidelity and acceptability of studies were mixed. Only five of the eight studies reported process evaluations of school-based digital interventions in the US (n=3), Spain (=1) and Australia (n=1), with the remaining being community-, family- or clinic-based digital interventions. The Australian-based study was the only study to include process evaluation data from both students and teachers, providing insights on both how the intervention was experienced by the target user (students) and teachers who have a role in supporting the implementation of the intervention in the school-setting. However, data were collected and analysed between 2012 to 2014 and only among low SES boys in New South Wales (NSW), thus pointing at the need for more recent process evaluations that also include disadvantaged adolescents from various geographical locations across Australia. The dearth of process evaluations on this topic highlights a critical gap in understanding the implementation of digital interventions among disadvantaged adolescents.

In a recent process evaluation of *Health4Life*, a universal digital school-based program targeting multiple lifestyle risk behaviours such as poor diet, alcohol and tobacco use, high SES adolescents reported greater odds of using skills they learned from the intervention in the future compared to low SES adolescents (Champion et al., submitted for publication). This suggests that SES may significantly influence the uptake and utilisation of intervention components. Although there were no significant differences in learned skills utilisation between regional and metropolitan areas, a moderation analysis of *Health4Life* revealed that geographical location moderated the intervention's effect (Egan et al., 2024). Specifically, in regional areas, adolescents in *Health4Life* reported greater odds of reporting poor diet compared to the control. Although SES has not generally been found to moderate intervention effects on other school-based interventions targeting lifestyle behaviours such as diet (Yildirim et al., 2011), or physical activity (Robbins et al., 2020; Wassenaar et al., 2021).

Therefore, additional investigation into the implementation outcomes among disadvantaged adolescents in *Health4Life* is warranted, particularly as these findings point at the complexity of intervention delivery across diverse contexts.

Against this backdrop, this study aims to conduct a comprehensive process evaluation of *Health4Life* among a sub-sample of low SES and regional adolescents across Australia, and their teachers, to elucidate the acceptability and feasibility of the intervention within these specific demographic contexts. Additionally, it seeks to identify areas for improvement and refinement, ultimately enhancing the intervention's effectiveness and relevance for disadvantaged adolescents.

5.3. Methods

5.3.1. Study Design

The full study design and procedure of *Health4Life* are reported in the published protocol (Teesson et al., 2020). Briefly, the Health4Life Study is large cluster randomised controlled trial aimed at reducing chronic disease risk and improving physical and mental health among adolescents that was implemented in 71 secondary schools across Australia in 2019 (6639 participants aged 11-14 years at baseline) (Champion et al., 2023). Data were collected at baseline, post-intervention, 12-, 24- and 36-months after baseline via self-report online or hardcopy questionnaires during class, with students and teachers in the *Health4Life* group completing process evaluation measurements at post-intervention. The current study examines a subset of post-intervention process evaluation questionnaire data from students and teachers from low SES and/or regional schools.

5.3.2. Participant Details

Seven intervention schools from low SES and/or regional areas were eligible for the current study. Low SES schools were identified based on their 2019 Index of Community Socio-educational Advantage (ICSEA) percentile score being in the bottom quartile (Australian Curriculum Assessment and Reporting Authority, 2023). ICSEA values, calculated by the Australian Curriculum, Assessment and Reporting Authority (ACARA) indicate a school's relative educational advantage or disadvantage, based on factors such as parental occupation and education, the percentage of Aboriginal and/or Torres Strait Islander student enrolment, and student and school's geographic remoteness. Schools with an ICSEA percentile below

25% were considered more educationally disadvantaged than at least 75% of schools in Australia. Regional school classification included schools outside of major cities according to the Australian Statistical Geography Standard Remoteness Structure, which categorises regions based on their access to services (Australian Bureau of Statistics, 2023). Accessibility decreases as remoteness increases, with areas classified as *inner regional*, *outer regional*, *remote* or *very remote*.

As no student or teacher data were collected from one of the eligible schools, the final sub-sample comprised six intervention schools. Three of these schools (50%) fell under the category of inner or outer regional, two (33.3%) were classified as low SES only, and one (16.7%) met criteria for both regional and low SES classifications. The majority of these schools were Government (83.3%) with one being an Independent school (16.7%). Five schools were located in NSW (83.3%), and one was in Western Australia (WA) (16.7%).

5.3.3. The *Health4Life* Intervention

Schools allocated to the intervention group implemented *Health4Life* during regular health education classes. The program consists of six co-designed 20-minute online modules, ideally delivered one-week apart with students completing them individually (Champion et al., 2020). Underpinned by social influence, social cognitive and self-determination theories to promote healthy behaviour change, the core component of each module features interactive cartoon storylines addressing health risk behaviours for chronic disease including poor diet, alcohol use, tobacco smoking, physical inactivity, poor sleep, and sedentary recreational screen time. The cartoon storylines interweave evidence-based information about health and social consequences of these behaviours, while also promoting resistance skills, normative education and autonomous motivation that underpin behavioural change theory (Michie et al., 2015). After completing each module, students complete short online quizzes to assess their knowledge. To reinforce content covered, factsheets for each module are available to both teachers and students and optional teacher-facilitated activities including online worksheets and homework tasks are provided. Students received personalised web-based feedback after each questionnaire on their adherence to national health guidelines. Additionally, students could access a companion smartphone app for further support and resources (Thornton et al., 2021). An overview of module content is provided in Appendix 4.2.

5.3.4. Process Evaluation Measures

5.3.4.1. Acceptability and areas for improvement

Student evaluation: Based on evaluation surveys from previous school-based prevention trials (Newton et al., 2010; Teesson et al., 2017; Vogl et al., 2009), students completed an online survey featuring eight questions assessing their satisfaction with *Health4Life*, content relatability, and program utility. Example questions included, *'Overall, how would you rate the Health4Life program?'* ('Very good', 'Good', 'Average', 'Poor', 'Very poor'), *'How relevant were the stories to experiences in your own life'* ('Completely relevant', 'Somewhat relevant', 'Unsure', 'Somewhat irrelevant', 'Completely irrelevant'), *'How likely are you to use the skills and information taught in the program in your own life'* ('Very likely', 'Likely', 'Unsure', 'Unlikely', 'Very unlikely'). Responses were converted into binary variables to determine positive or unsure/negative evaluations. Two additional open-ended questions asked participants to provide feedback on one positive and one negative aspect of the program, capturing qualitative insights on the facilitators and barriers to program acceptability, respectively. The full student evaluation survey is provided in Appendix 4.3.

Teacher evaluation: Teachers completed a 12-question online or hardcopy evaluation survey assessing program satisfaction and quality, ease of implementation and use, student satisfaction and engagement, and likelihood of using and recommending *Health4Life*. Example questions included, *'How would you rate the Health4Life program in comparison to other school-based health education programs?'* ('Much better than most programs', 'Better than most programs', 'The same as most programs', 'Worse than most programs', 'A lot worse than most programs'), '*How easy did you find it to implement the Internet-based component of Health4Life program?'* (Very easy', 'Easy', 'Average', 'Difficult', 'Very difficult'), '*How much do you think the students liked the cartoon-based stories?'* ('Liked a lot', 'Liked a little', 'Average', 'Disliked a little', 'Disliked a lot'), *'How likely would you be to use the Health4Life course as a teaching resource in the future?'* ('Very likely', 'Likely', 'Undecided', 'Unlikely', 'Very unlikely'). Two additional open-ended questions asked participants to provide feedback on improving the program could be improved and any additional comments about the modules. The full teacher evaluation survey can be found in Appendix 4.4.

5.3.4.2. Fidelity and Feasibility

Teachers were asked to complete an online or hardcopy version of a teacher logbook survey, to assess whether the six *Health4Life* modules and corresponding intervention components were implemented as intended (fidelity) and the practicality of implementing *Health4Life* (feasibility). The survey included a range of questions focused on several fidelity measures including adherence (i.e. whether students completed the online cartoon storylines for each module, and if teachers reviewed student summaries with their class or instructed students to download them), dose (i.e. the number and selection of activities students completed), and quality (i.e. teachers' perceptions of the level of student engagement for each module). To ensure consistent delivery across all schools, the research team monitored intervention schools' completion of modules via the intervention website and encouraged teachers to dedicate class time for their students to complete the module if it had not been completed in the scheduled week. Lastly, an open-ended question invited teachers to share any comments or concerns they had about each module. Further details about the questions asked in the teacher logbook survey can be found in Appendix 4.5.

5.3.5. Analysis

Quantitative data were descriptively analysed in IBM SPSS Version 28.0.0.0 (190) to provide sample characteristics information and percentage agreement with quantitative survey item questions. Qualitative analysis of both student and teacher open-ended responses were conducted in Microsoft Excel and followed a codebook thematic analysis approach (Braun & Clarke, 2021; Clarke & Braun, 2017) to further describe the acceptability and feasibility of the intervention among disadvantaged adolescents. This approach was chosen to facilitate multiple team members coding different sections of the data efficiently. For student responses, the researchers immersed themselves in the data, repeatedly reviewing it to gain familiarity. Through an iterative and inductive approach, initial codes were generated and refined to create a codebook prior to discussing it with the authorship team. This codebook was then used to systematically code all open-text student survey responses to allow for a coherent and interpretive analysis of the data. The first author continued to develop themes, which were then reviewed, defined and named collaboratively with the authorship team. Similarly, for teacher responses, the first author coded each open-text response, adjusting codes as needed to describe developing insights of those data. Salient themes with explanatory value were then constructed, defined and named. In collaboration with the authorship team, themes were discussed and further refined resulting in a shared

understanding of where the intervention fell short in meeting the needs of disadvantaged adolescents, along with suggestions for improvement.

5.4. Results

Of the 364 students attending the six schools in the current study, 214 (58.8%) completed the student evaluation surveys after completing the *Health4Life* program. The mean age of students was 12.77 (SD=0.48), predominantly identifying as male (67.5%) and based in NSW (96.7%). Further details on student characteristics are reported in Appendix 4.6. Regarding teacher participation, out of the twenty-five teachers across these six schools who registered an account on the *Health4Life* website, 14 (56%) completed both the teacher logbook and evaluation survey, 2 (8%) completed the teacher evaluation survey only, and 1 (4%) completed the teacher logbook only.

5.4.1. Student Evaluation

Students' overall response to *Health4Life* was generally positive, with 66.4% (142/214) of students rating *Health4Life* as good or very good. 65.7% (140/213) found the information helpful, and 80.8% (172/213) reported that the skills and information they received in the program will help them to be healthy in the future. However, only 52.1% (111/213) found the stories relevant to their own experiences and 44.1% (94/213) reported that they would recommend *Health4Life* to their friends. Further details about student responses are in Appendix 4.7.

Based on 213 student responses to 'one good thing' about *Health4Life*, we developed three dominant themes regarding facilitators for *Health4Life* acceptability (summarised in Table 5.1). Briefly, students commonly expressed appreciation for the educational value of *Health4Life*, citing informative evidence-based information on health concepts, and helpful and practical assistance for making healthy choices. Many found the stories and content engaging, with some describing it as relevant and relatable. Furthermore, students commended the engagement and interactivity of *Health4Life*, perceiving the cartoons conveyed information in an entertaining and accessible way, the program was fun, easy to use, and the online format offered convenience and a different learning experience. However, four students reported 'nothing good' about *Health4Life* and twenty-four responses were

indecipherable, suggesting they were potentially disengaged with the program or their response rate was influenced by procedural factors on how the evaluation survey was administered not facilitating quality responses (e.g. they may have been encouraged by their teacher to complete the survey at home if they were not present in class, which has been found to decrease response rates (Bidonde et al., 2023), or they may have had limited time to complete the survey in class due to unexpected circumstances, thus affecting response quality).

Table 5.1. Summary of dominant themes regarding facilitators for *Health4Life* acceptability from open-ended student responses

Themes and sub-themes	Description	Example quote
Educational value		
Informative (n=48)	informative evidence-based information on health-related concepts and the consequences of unhealthy behaviours	"*I really like all the facts and statistics*"
Helpful (n=41)	helpful for making healthy choices	"*it can help me in the future to stay healthy*."
Stories and content:		
Stories (n=23)	engaging stories – particularly backstory and character development	"*It has a good story line*"
Relevant and relatable (n=12)	relevant and relatable to students' lives and interests	"*It was very relevant and it was something the class WANTED to do, not just another bit of school work*."
Engagement and interactivity		
Cartoons (n=19)	cartoons conveyed information in an entertaining and accessible way	"*the cartoons were pretty interesting i could'nt wait until i got into pdhpe so i could continue the story*"
Fun (n=11)	fun way to learn, preferable to traditional classwork	"*it was fun but i leart alot*"
Easy (n=7)	easy to use and understand concepts taught	"*It was easy to understand because it was a cartoon*."
Online (n=4)	convenient online format without extensive written work	"*use a computer"*

We developed four key themes regarding barriers to *Health4Life* acceptability based on the 214 student open-text responses to 'one bad thing' about *Health4Life* (summarised in Table 5.2). The overarching theme revolves around the need for improvement in content delivery

and the technical execution of the program for this sub-sample of students. A prominent aspect relates to content quality, where some students highlighted issues related to relevance (in contrast to findings above), storyline coherence, and perceived certain aspects as boring. Furthermore, there were structural concerns, particularly regarding the length of modules, relevance of questions, and contradiction between the program messaging to reduce screen time and increase physical activity when completing the program online during Health and Physical Education lessons. Technical and design-related issues, including website functioning, graphic design, and accessibility concerns were frequently reported. Some students expressed overall dissatisfaction with the entire program, while others mentioned the required engagement, such as homework tasks, as a source of discontent. However, 41 responses were indecipherable/nonsensical.

Table 5.2. Summary of key themes regarding barriers to *Health4Life* acceptability from open-ended student responses.

Themes and sub-themes	Description	Example quote
Content quality		
Relevance/relatability (n=16)	lacked relevance, relatable language, diverse perspectives, and real challenges students face	"*some of the info doesn't really include country kids*"
Boring (n=15)	boring aspects including repetitive, slow-paced, overall unengaging content	"*it was boring sometimes*"
Storyline issues (n=14)	storyline issues including confusing, unrealistic scenarios, lacked long-term character outcomes, potentially encouraged unhealthy behaviours	"*that its cringy*"
Structural concerns		
Too long (n=20)	modules were too long	"*the modules went for too long i believe there should only be 3-4 modules.*"
Too short (n=11)	modules were too short, needed more detailed storylines and character development	"*it should go for longer*"
Contradiction between program format and health-promoting messaging (n=5)	contradiction between *Health4Life* promoting physical activity and reduced screen-time when using screens for program	"*you are telling us to be more active yet we spend hours on a screen completing the activities*"

Technical and design issues		
Website functioning (n=13)	website functioning issues including slow loading times, glitches, and lag	"*The lag and glitches of the website*"
Graphic design (n=11)	unappealing graphic design including character style, and text outside speech bubble borders	"*Bad graphics*"
Accessibility (n=8)	accessibility impacted by too much text, lack of voice-overs, and reliance on internet access	"*not all people can read or have internet*"
Overall dissatisfaction		
Everything (n=5)	everything is unsatisfactory	"*all of it*"
Required engagement (n=3)	required engagement with materials including homework participation	"*being made to do it as homework*"

5.4.2. Teacher Evaluation

Most of the 16 teachers who completed the teacher evaluation survey rated *Health4Life* positively (14/16; 87.5%) and found the internet-based component easy to implement (14/16; 87.5%). 81.3% (13/16) perceived the cartoon stories held the students' attention well/very well, and considered the educational quality of the additional classroom activities in the online teacher centre to be good to very good (14/16; 87.5%). However, only half would recommend *Health4Life* to others (8/16; 50.0%). Further details of teacher survey responses to quantitative questions are in Appendix 4.8. In response to how *Health4Life* could be improved for the future some teachers perceived the program was good as is, stating '*I don't think there is anything at this stage that I could suggest, it is a great program.*', whereas others provided suggestions regarding accessibility, the user interface and experience, engagement and relevance, timeframe expectations for users, and content clarity and appropriateness.

5.4.2.1. User interface and experience (n=10)

Similar to students, teachers suggested addressing website glitches as this impacted user experience, and ensuring speech bubble text on cartoon slides fits within borders. They recommended removing the repetitiveness of student worksheets, making them dynamic, and embedding them within the *Health4Life* platform to eliminate the need for printing. Moreover, teachers proposed adding minimum time requirements for each cartoon slide to assist with getting students to work at similar paces and prevent them skipping ahead without

engaging with the content. Although teachers noted that questions and interactive activities embedded within the modules helped engage students.

> '*Found it hard to stop some students from skipping through the cartoon without reading it properly. The use of questions and interactive activities through the online modules engaged the students*.' (Teacher)

Teachers also suggested streamlining administrative tasks by increasing teacher account privileges for resetting student passwords quickly and efficiently and the ability to set generic passwords for individual classes.

5.4.2.2. Engagement and relevance (n=5)

Teachers praised the engaging stories that seamlessly integrated essential information, whilst maintaining student interest across different ability levels. However, some expressed that despite *Health4Life* providing students with potential benefits, student apathy towards new learning experiences is common, indicating a need for a more engaging program. A few teachers discussed variations in student engagement and module completion, with students either racing through independently or struggling to finish them.

> '*The engagement and completion of modules depended on the ability of students. Some students raced through and even completed the modules at home (even though they had been told to complete them in class) while other students did not complete all modules…*' (Teacher)

5.4.2.3. Content clarity and appropriateness (n=5)

Teachers suggested improving content clarity and assessing the appropriateness of some content. Specifically, concerns were raised regarding the difficulty in understanding some of the questionnaires, particularly the sleep questionnaire. Additional feedback included perceiving some activities as overly simplistic and requiring further information to improve their educational value, more content or longer lessons to cover one school term, and redistributing the workload across the modules as some had too much content and activities whereas others were lacking. Therefore, a thorough review and testing of all materials are needed to ensure they address these concerns effectively.

'*We found some modules had too much content/activities and others didn't have enough for a whole lesson. Perhaps adjusting the amount of work in some lessons would improve …*' (Teacher)

5.4.2.4. Accessibility (n=4)

Some teachers noted limited access to computer labs in certain schools, which could impact participation for students without personal devices. Others commented on the challenge of balancing using the program as prescribed with catering to individual student learning needs. Moreover, they discussed the importance of voiceovers to accompany the cartoon slides, not only to support students with lower literacy levels but also to improve engagement. Therefore, an offline or adapted format may be necessary to overcome these issues to ensure *Health4Life* is accessible to students with diverse backgrounds and learning needs.

'*Audio options for students who have poor reading skills*.' (Teacher)

'*… Easy to access and use. My school each high school student has to have a device so makes access easy- in other schools where this is not the case it may have proved harder to access computer labs*.' (Teacher)

5.4.2.5. Timeframe expectations for users (n=2)

Lastly, teachers mentioned discrepancies between advised and actual module completion timeframes, indicating more accurate instruction is required to aid in lesson planning. Some teachers facing time constraints chose to double up lessons to cover the curriculum. To ensure more teachers understand the realistic timeframes and program format flexibility, and accommodate varying time constraints, clear documentation of this must be included in the program implementation guide available to teachers.

'*… we were told around 20 minutes per module- realistically it took around 40 minutes for our Year 7 students to read each module. Just advising of a more realistic timeframe*.' (Teacher).

5.4.3. Teacher Fidelity

Teacher logbook data collected from 16 teachers are reported in Appendix 4.9. Most teachers indicated that the cartoon storylines were fully completed, except for Modules 5 and 6, primarily due to lack of time. Teachers reported students were somewhat to very engaged 85.7% to 100% across modules, with the greatest engagement reported for Module 3 (100%). Module 3 also had the most reviewed summary sheets for students and teachers (93.3%). Module 4 demonstrated the highest completion rates for both the online interactive activity (86.7%) and the three offline activities (88.9%). None of the recommended/homework tasks across modules were fully completed. Teachers expressed concerns about accessibility, login issues and too much content in Module 1, while Module 2 feedback pertained to graphic design issues affecting text readability and the need for more content. Modules 5 and 6 were positively reviewed, with Module 5 complimented for its engaging activities, particularly the interactive sleep hazards activity, while Module 6 was commended as a "*good summative lesson*" (Teacher).

5.5. Discussion

Few studies have reported on process evaluations of school-based digital interventions targeting poor diet, alcohol use and tobacco smoking among disadvantaged adolescents (Egan et al., 2023), leaving a significant gap in the literature regarding the implementation and relevance of such interventions for this population. The current study reports on the implementation of a universal school-based digital program targeting multiple behaviours among disadvantaged adolescents in Australia. The *Health4Life* intervention received positive feedback from both teachers and students, yet only half of teachers and 44.1% of students expressed intentions to recommend the program to others. This is in contrast to the process evaluation among the entire sample which demonstrated a more positive overall experience and higher rates of recommendation (Champion et al., submitted for publication). This highlights the need to adapt and optimise interventions with the distinct population in mind. Several areas for improvement and refinement were identified in the present study to improve the effectiveness and relevance of the intervention for disadvantaged adolescents.

Compared to process evaluation findings from the entire sample, this sub-sample of students evaluated *Health4Life* less favourably. For instance, a smaller proportion of students rated the program positively (66% versus 75% among the entire sample), enjoyed the stories (63% versus 75%), found the information helpful (65% versus 76%), were likely to use the skills

and information in their own life (60% versus 70%), and would recommend *Health4Life* to friends (44% versus 50%). Despite the subsample of students in the current study reporting that the entertaining online cartoons made health messaging accessible, these lower ratings suggest the program has limited relevance for disadvantaged adolescents. Interestingly teacher evaluations of *Health4Life* in this study aligned closely with those of the entire sample and were mostly positive. Teacher fidelity data was also comparable to the entire sample, with similar levels of student engagement (~92% versus ~85%) and slightly more activities completed per module (3 versus 2). However, only 50% of these teachers would recommend *Health4Life* to others compared to 64% in the entire sample. The discrepancy may reflect teachers' recognition of *Health4Life*'s value and potential in low SES or regional contexts where comparable programs may be scarce, whilst acknowledging the need for content and technical delivery improvements which was also noted in the entire sample process evaluation, alongside *Health4Life*'s limited contextual relevance for disadvantaged adolescents. These findings are consistent with other school-based digital interventions for disadvantaged adolescents. A recent systematic review reported that while participants generally expressed high satisfaction with the interventions, the feasibility, fidelity and acceptability of studies were mixed (Egan et al., 2023). For instance, in one study (Lubans et al., 2016; Smith et al., 2014) only 44% agreed or strongly agreed they enjoyed using the intervention app, potentially due to limited engaging features and lack of co-design. Another study (Nollen et al., 2014) reported high enjoyment scores (mean = 4.5/5; SD = 0.9) and participant engagement with the program on 63% of days, which may be due to conducting in-depth co-design with the target population and addressing their needs. It is worth noting that the teacher-reported fidelity data regarding students' *Health4Life* module completion (that is, 85.7% to 100% completed module cartoon storylines) is similar to intervention completion of other school-based digital programs among disadvantaged adolescents (Egan et al., 2023). These completion rates coupled with high teacher-reported rates of student engagement (~92%) are positive particularly as engagement is a key element for improved intervention effects, albeit only 64% (16/25) of teachers completed the teacher logbook.

Themes developed from the qualitative data in the current study revealed key issues resonating with challenges faced by low SES/regional adolescents. For instance, students critiqued *Health4Life'*s content quality and relevance of stories to their own experiences. They raised structural concerns about the program's length and the requirement to engage with *Health4Life* via computers during health education classes, which seemed discordant

with its healthy behaviour messaging. Both students and teachers criticised the accessibility of the program for diverse backgrounds and literacy levels, echoing broader challenges low SES and regional adolescents face. Differences in digital literacy among adolescents from different socio-economic backgrounds, including how they access and use technology, may have shaped how relevant the intervention was to them. Indeed, Lim et al. (2024) have suggested that low SES adolescents engage with digital media differently compared to their more advantaged peers, which may influence their digital literacy. For example, in one study (Harris et al., 2017) there were differences in computer use among a sample of adolescents in Western Australia. Specifically, low SES adolescents were less likely to access computers in school than high SES adolescents. Additionally, they were more likely to use their home computer for non-academic activities such as chat rooms and multimedia (e.g. video and music), whereas high SES used their home computer learning programs to improve their academic skills. Considering this, incorporating support mechanisms such as greater visual material and chatbots may be potentially helpful features to compensate for SES differences (Maenhout et al., 2022).

Nevertheless, this study identified refinements needed to improve the student and teacher experience, including: adding dynamic features (e.g. embedding activity worksheets); more appropriate content (e.g. addressing repetitive worksheets); clearer documentation of program flexibility to accommodate time constraints; improving accessibility (e.g. voiceovers, reducing text on screen); fixing issues such as website glitches and text overflowing borders; setting minimum time requirements on cartoon slides to ensure students work at similar paces; and granting teachers greater administrative privileges (e.g. reset passwords easily). For improved implementation suggested refinements include: balancing the workload across modules (e.g. content redistribution and additional materials for certain modules), catering better to diverse learning needs and environments (e.g. offering flexible delivery modes with more offline content), and providing resources to improve digital literacy (e.g. such as step-by-step instructions on how to log in and use the website – both written and via a recorded video –, adding a chatbot to allow for instant assistance). These points suggest that without adapting *Health4Life* to disadvantaged adolescents' context, their sustained engagement and the program's utility may be compromised.

Indeed, adapting *Health4Life* to the specific skills, needs and barriers of disadvantaged adolescents is essential for ensuring its relevance and for promoting effective engagement

with the intervention (Yardley et al., 2016). This requires contextual adaptation leveraging co-design approaches, including disadvantaged adolescents and their teachers as support, to appropriately address feedback and refine the program content, delivery methods, and engagement strategies. Involving both students and their teachers in the adaptation process is important as they may experience the program differently. For instance, the program's design and format may align more closely with teachers' pedagogical perspectives on targeting lifestyle risk behaviours among adolescents than with the students' real-life experiences. Nonetheless, considering that teachers facilitate the implementation of *Health4Life* with their students, ensuring their experience is seamless and enjoyable is paramount to its success.

Although *Health4Life* was co-designed with students and teachers, recruitment for this development phase lacked a representative mix of schools with varying SES and geographic distribution, predominantly involving metropolitan and more affluent schools. This may partly explain the less favourable process evaluation outcomes in the current study. Nevertheless, moving forward, the co-design adaptation process with disadvantaged adolescents and their teachers should be iterative with development and implementation intertwined to allow for ongoing refinement and facilitate participation. Al-Dhahir et al. (2022) identified this approach as a facilitator in digital lifestyle intervention participation among low SES adults, and it could have addressed early issues with *Health4Life* teachers in the current study mentioned, including student difficulties with logging in and registering. Confidentiality and privacy concerns are also important factors to consider. They have been identified as prerequisites for participation in digital mental health programs among vulnerable young people, specifically school leavers, which is associated with experiencing socioeconomic disadvantage (Kuosmanen et al., 2018). Furthermore, incorporating the broader social networks of disadvantaged adolescents, including parents and peers may improve the acceptability and feasibility of the intervention. This is because peers can influence adolescent behaviours and peer-led interventions can be effective at targeting lifestyle risk behaviours (Veenstra & Laninga-Wijnen, 2022). Similarly, parental factors and behaviour modelling can influence adolescent behaviours (e.g. dietary composition), and parent-based interventions delivered alongside school-based programs have shown success in improving adolescent outcomes (Champion et al., 2022; Osman et al., 2024). The *Health4Life* team are currently evaluating the accompaniment of a parent-based program with *Health4Life* among disadvantaged adolescents.

5.5.1. Strengths & Limitations

This study has several strengths, including gathering detailed feedback from both disadvantaged students and their teachers to provide an understanding of *Health4Life*'s acceptability for this demographic and areas for refinement. The inclusion of schools from diverse regions, including resource-constrained settings, enhances the relevance of the findings across various educational contexts. The mixed-methods approach, combining quantitative data (e.g., program ratings) with qualitative feedback enriched the analysis to provide deeper insights into how and why *Health4Life*'s acceptability and implementation differed for disadvantaged adolescents. These findings have important implications for designing and delivering interventions to different subgroups, including low SES and regional adolescents.

However, there are some limitations. Teachers from one inner regional independent WA school did not complete the teacher logbook nor the teacher evaluation survey, limiting comparative analysis with the one outer regional WA school that provided data. The WA teachers who provided data only completed the teacher evaluation and did not submit any teacher logbook data, restricting our understanding of *Health4Life* in this region. The use of teacher-led surveys may have introduced response bias, with potentially more engaged and motivated teachers actively providing evaluation and logbook data. Thus, future studies should triangulate data with objective measures (e.g. from the intervention website) to corroborate teacher survey responses and provide information for teachers who do not complete the surveys. Only one author coded qualitative teacher data which may have limited richness of analysis, although thematic analysis does not always require multiple reviewers (Byrne, 2022). Finally, the findings may not be fully generalisable due to the limited number of schools and regions involved in the study. Future research with a broader sample is needed to validate these results.

5.5.2. Conclusion

This study addresses a notable gap in the literature by examining the implementation and relevance of a universal school-based digital intervention targeting lifestyle risk behaviours among disadvantaged adolescents. The findings reveal key areas for refinement including improving content relevance and technical execution to better resonate with disadvantaged adolescents, and ensuring accessibility for students with diverse backgrounds and learning

needs. Future iterations of *Health4Life* should leverage iterative co-design approaches involving both disadvantaged adolescents and teachers to refine the program and ultimately enhance its engagement, relevance, and effectiveness. The implications of the study findings have broader applicability in providing valuable guidance for optimising the design and implementation of digital interventions among diverse populations.

Chapter 6

A mixed-methods study among adolescents and teachers in Bogotá, Colombia: Adapting the OurFutures Alcohol Program

Preface

In upper-middle-income countries, such as Colombia, early alcohol initiation is prevalent, yet standardised alcohol prevention programs in schools are lacking. Adapting effective interventions from high-income countries, such as Australia, provides a potentially cost-effective alternative to developing new interventions. However, there is limited evidence on the acceptability of existing evidence-based eHealth interventions when applied in Colombian contexts. This chapter addresses this gap, by reporting on the findings from a mixed-methods case study that collected and analysed insights from adolescents and teachers in Bogotá, Colombia via focus groups and interviews/online surveys. This study evaluated the acceptability of the *OurFutures Alcohol Module,* an effective Australian-developed eHealth, school-based, alcohol prevention program in the Bogotá context. These findings represent a crucial first step towards informing the adaptation of the program for use in Bogotá, Colombia.

This chapter addresses the fifth aim of this thesis (Table 1.2):
Assess the acceptability and potential global scalability of an effective eHealth school-based alcohol use prevention program, the OurFutures Alcohol Module, among disadvantaged adolescents overseas such as Bogotá, Colombia.

This mixed-methods study is available in Appendix E and has been published as:
Egan, L., Ospina-Pinillos, L., Champion, K. E., Newton, N.C., Ballen Alonso, P.V., Teesson, M., & Gardner, L.A. (2024). A mixed-methods study among adolescents and teachers in Bogotá, Colombia: Adapting the OurFutures Alcohol Program. *Health Promotion International*. 39(6). https://doi.org/10.1093/heapro/daae152

6.1. Abstract

Early onset of alcohol consumption among Colombian adolescents, highlights the need for effective and accessible preventive interventions. This project aimed to conduct formative work to inform the adaptation of an effective eHealth alcohol use prevention program originally developed in Australia, the *OurFutures Alcohol Module,* to the Bogotá context. Twenty-six adolescents and 10 teachers in Bogotá participated in the study. We used a mixed-methods approach comprising interviews, surveys and semi-structured discussions to evaluate the acceptability of OurFutures. Study materials were translated into Spanish before conducting three 1.5-hour focus groups with adolescents (aged 11-15; n = 26), and 1-hour interviews or online surveys with teachers to assess attitudes towards alcohol use and the acceptability of one lesson from the *OurFutures Alcohol Module* in the Bogotá context. Qualitative data were analysed thematically, and descriptive analyses of quantitative data reported percentage agreement for survey questions. Overall, 96% of students and 89% of teachers expressed strong satisfaction with the *OurFutures Alcohol Module* lesson. Most students (96%) liked its storyline and character portrayal, and most teachers (80%) said they would use *OurFutures* with their students. Participants provided feedback for improving program relatability, including adapting scenarios, character names, clothing and language to align with the Bogotá context and resonate with Colombian adolescents. This study marks the first step in informing the adaptation of the *OurFutures Alcohol Module* to the Bogotá context and highlights key considerations for cultural adaptations of other substance use prevention interventions. This research underscores the importance of place-based end-user involvement in co-designing adolescent prevention interventions.

6.2. Introduction

Alcohol consumption during adolescence is associated with increased risk of alcohol-related harms, and future substance use (Australian Institute of Health and Welfare, 2021b; Hamidullah et al., 2020; Ryan et al., 2019). According to the 2019 Colombian National Survey on the Use of Psychoactive Substances (ENCSPA), 46.3% of young people aged 12 to 17 years had consumed alcohol at least once, with 12.1% over the past 30-days (National Administrative Department of Statistics. DANE, 2020). Alarmingly the average age of first alcohol consumption among this cohort is 13.9 years. Initiation at 14 years or younger among Colombian youth has been associated with two-and-a-half times the risk of hazardous alcohol use and four times the risk of substance use in adulthood, compared to those who first consume alcohol at 18 years (Pérez Gómez et al., 2011). This trend aligns with Australian

findings, where earlier initiation is associated with hazardous drinking at a younger age (Gardner, Stockings, et al., 2024). According to the recent WHO Global Status Report on Alcohol and Health and Treatment of Substance Use Disorders (WHO, 2024c), 23.7% of young people aged 15-19 years in Colombia are current drinkers, which is higher than in neighbouring countries such as Guatemala (17.4%) and Honduras (19.6%). Additionally, 12.4% of young Colombians aged 15-19 years report binge drinking, defined as consuming 60 grams or more of pure alcohol (equivalent to six standard drinks) at least once in the past month. Although the 12.4% rate of binge drinking among young Colombians is lower than in neighbouring countries such as Argentina (28.3%), it remains a significant public health concern (WHO, 2024c). Binge drinking among young people is associated with acute consequences such as alcohol poisoning, motor vehicle accidents and violence, as well as long-term consequences including alterations to general brain functioning and substance use dependence (Kuntsche et al., 2017; WHO, 2024c). Factors that may influence drinking patterns in Colombia include cultural and social normalisation of alcohol consumption, positive attitudes towards alcohol, and low-risk perception (Londoño-Pérez & Carrasco-Aravena, 2019). Early intervention and prevention is therefore critical for safeguarding the health of Colombian youth.

School-based alcohol prevention interventions are an effective approach for delivering long-lasting health and economic benefits (Kuklinski et al., 2021; Newton et al., 2022). Ensuring successful delivery of prevention interventions involves careful consideration of available resources (e.g., personnel, training, and financial costs), and the target population's needs. Given approximately 1 in 4 of the Colombian population lives in rural regions (National Administrative Department of Statistics. DANE, 2022), electronic health (eHealth) interventions (e.g., computer-, web-, mobile-, or telephone-based) may be a viable option as they can be accessed remotely and at little cost to the end user, and provide increased implementation fidelity and student engagement (Newton et al., 2017). There is substantial evidence to support the effectiveness of school-based eHealth interventions in reducing alcohol use and intentions to use alcohol (Alison Hutton et al., 2020; Kazemi et al., 2021; Martinez-Montilla et al., 2020; Newton et al., 2022; Voogt et al., 2013). However, to our knowledge there are currently no school-based eHealth interventions targeting alcohol use among Colombian youth, nor are there standardised alcohol prevention programs established in Colombian schools.

Developing a sustainable and effective prevention intervention can be expedited by building upon evidence-based programs known to be effective at driving behaviour change. The Australian *OurFutures prevention model* (formerly known as Climate Schools) has been used to develop a suite of web-based substance-use prevention programs for school-aged students. The *OurFutures* model was developed by researchers at Australian universities funded by government and philanthropic grants. The development involved collaboration with students, teachers, and health and education experts, aimed at offering programs that overcome barriers to implementing high-fidelity programs to address the critical need for early prevention of substance use (Newton et al., 2009; Vogl et al., 2012). Based on a harm minimisation and social influence approach, the core component of the program utilises interactive online cartoon storyboards to engage and educate students, with optional teacher-facilitated activities to reinforce the core content. The *OurFutures* programs have been rigorously evaluated across 8 large cluster randomised controlled trials in Australia (240 schools, >21,000 students, up to 7-year follow-up), demonstrating effectiveness in preventing the uptake and harmful use of alcohol and other drugs, reducing harms related to alcohol and other drugs, and improving attitudes towards alcohol among Australian adolescents (Newton et al., 2020; Slade et al., 2020), up to 7 years after intervention delivery (Newton et al., 2022). This model offers promise for international adaptation, with adapted versions already developed for multiple countries, including the United Kingdom (Newton et al., 2014) and Germany (Röhrig et al., 2023). However, recognising that the *OurFutures Alcohol Module* was originally designed for Australian adolescents aged 13-14 years, and the average age of first alcohol consumption in Colombia is 13.9 years, potential adjustments for earlier delivery may be warranted to align with the cultural and developmental context of Colombian adolescents.

Considering the diversity of Colombia's regions, Bogotá, the nation's capital and largest city, stands out as an ideal starting point for conducting this formative work. With over 8 million inhabitants from various parts of the country, Bogotá's diverse population presents an opportunity to encounter a broad spectrum of races and cultures on a smaller scale (National Administrative Department of Statistics. DANE, n.d.). To ensure the acceptability and feasibility of the *OurFutures Alcohol Module* within the Bogotá context, we first require an understanding of the individual, interpersonal, and cultural beliefs associated with alcohol consumption among Bogotán youth (Londoño-Pérez & Carrasco-Aravena, 2019) and feedback from young people and teachers on the program in its current form. Collaborating

with and including end users in the intervention design process is crucial, as it can influence the development, engagement, and outcomes of an intervention (Slattery et al., 2020). Therefore, the aim of this study was to seek feedback from Bogotán young people and teachers as a first step towards guiding the adaptation of an effective eHealth school-based prevention program (*OurFutures Alcohol Module*) for the Bogotá context.

6.3. Methods

6.3.1. Study Design

This study followed a mixed-methods case-study design, collecting data from focus group sessions with students, and interviews or online surveys with teachers. This approach was chosen based on established frameworks and methodologies for effective adaptation led by team members NN, MT (Newton et al., 2014) and LO-P (Ospina-Pinillos et al., 2020), facilitating a comprehensive exploration of participant attitudes toward alcohol use, the acceptability of *OurFutures* and identifying areas of improvement to suit the Bogotá context. This study was approved by the University of Sydney Human Research Ethics Committee (HREC 2022/875) and Research and Ethics Committee of Pontificia Universidad Javeriana (HREC 2023/105).

6.3.2. Participants & Recruitment

One school in Bogotá was invited to participate via an invitation letter to the school principal in July 2023. This specific school was chosen due to established professional relationships between the school and the research team and because they had previously expressed interest in participating in research studies. The school is a large public school catering to students attending Preschool, Primary School (grades 1-5), Lower Secondary School (grades 6-9), and Upper Secondary School (grades 10-11). The school primarily serves populations facing socioeconomic disadvantage, including those experiencing economic hardship and migrants. This context is particularly significant as research indicates that socioeconomic disadvantage is associated with increased substance use, including alcohol consumption (Degenhardt et al., 2016). Therefore, selecting this school allowed for the provision of evidence-based resources to an underserved population that may have limited access to prevention programs, and the findings may therefore be especially important for populations at higher risk of alcohol use.

Eligible participants were adolescents aged 11-15 years proficient in Spanish for focus groups, and teachers for interviews or online surveys. Students from grades 5-7 were selected by their teachers to participate, and information about the study was disseminated to school staff via the primary contact. Two additional teachers from separate secondary schools in Bogotá were recruited following LO-P's lecture to Master of School Mental Health students, where the study was promoted to ensure a sufficient number of teachers participated in the study. Adolescents were required to obtain written parental consent and give their assent to participate, and teachers were required to provide active consent. As reimbursement for their time, students received scholarly goods valued at COP$30.000 (approximately AUD$10) and teachers received a COP$50.000 (approximately AUD$17) voucher for their time.

6.3.3. Procedures

Study materials, including focus group and interview guides, online surveys for adolescents and teachers, and an alcohol factsheet for adolescents, were translated by a native English speaker fluent in Spanish (LE). These translations were then reviewed by an official Spanish translator to ensure accuracy, followed by review for linguistic and cultural relevance by the Colombian researchers (LO-P and PVBA). The *OurFutures Alcohol Module* was translated into Spanish using the in-built translation software, 'Kanzi', on the *OurFutures* website. As a precaution for potential internet connectivity issues at the participating school or for teachers, one lesson was also downloaded as a hardcopy PDF version. Subsequently, between August and October 2023, focus groups and interviews were facilitated in Spanish by the research team (LE, LO-P, PVBA), guided by a semi-structured format, and audio-recorded for transcription. All surveys were administered in Spanish via REDCap.

Three 1.5-hour student focus groups were held at the secondary school in Bogotá. Part one of each session explored participants' attitudes and perceptions towards alcohol use. Subsequently, participants reviewed one lesson from the *OurFutures Alcohol Module* and provided feedback on the program's relatability and acceptability within the Bogotá context. Towards the end of the session, participants completed a brief evaluation survey and commented on the acceptability of an age-appropriate debrief alcohol factsheet. Participants could keep the debrief factsheet, which contained factual information about alcohol including its effects and potential risks of alcohol consumption during adolescence, as well as contact information for LO-P should they require further information. LO-P is a registered psychiatrist and was available as part of duty of care protocols to guide participants towards

appropriate help if needed. Additionally, participants were provided with contact details for separate support services accessible via email, WhatsApp or over the phone, ensuring they had access to helpful resources.

Teachers reviewed one lesson from the *OurFutures Alcohol Module* prior to participating in the 1-hour Zoom interview or online survey (based on their preference). Both the interview and survey featured similar questions as detailed in the appendices pg. 7-32. Part one of the interview or online survey focused on attitudes and perceptions about alcohol consumption among young Colombians and alcohol education in Colombian schools. Subsequently, teachers provided feedback on the relatability and acceptability of the *OurFutures Alcohol Module* lesson within the Bogotá context.

6.3.4. Materials

The *OurFutures Alcohol Module* is a universal eHealth school-based program, originally developed for Australian adolescents aged approximately 13-14 years. Consisting of six cartoon-based lessons with accompanying teacher-facilitated activities aimed at decreasing alcohol misuse, the module is embedded within the school health curriculum and requires no formal teacher training. A summary of lesson content is provided in Appendix 5.1.
Due to poor internet speed at the participating school, a lesson from the *OurFutures Alcohol Module* was provided as a hardcopy PDF version in Spanish for all focus group sessions. Most participating teachers evaluated the same hardcopy PDF version for this reason, with the exception of two teachers from different schools who reviewed the lesson via the *OurFutures* website. Focus group participants received a printed one-page alcohol factsheet to review and keep (see Appendix 5.2). The focus group and interview guides, and online surveys administered to adolescents and teachers, can be found in Appendix 5.3, Appendix 5.4, Appendix 5.5 and Appendix 5.6.

6.3.5. Analysis

Quantitative data were analysed using R version 4.2.2. Descriptive analyses were performed to report sample characteristics and percentage agreement for each survey item. Qualitative data including transcripts from focus groups and interviews, along with collected open-ended survey data were analysed using reflexive thematic analysis in NVivo by two researchers (LE and PVBA) to construct key themes and insights (Braun & Clark, 2006; Braun et al., 2023;

Terry et al., 2017). The research team adopted an experiential orientation to the data by coding significant quotes independently and then discussing coding differences to improve reflexivity and develop richer interpretations, before developing and grouping meaning-driven themes. This inductive approach allowed for participant-driven discussion priorities, ensuring a genuine representation of feedback. Data were anonymised to protect confidentiality. LE and PVBA recognised their varying assumptions that may have influenced the analysis. LE, a native English speaker with Spanish as a second language and substantial experience in Australian research contexts, particularly in chronic disease risk behaviours among young people, may have brought a broader, more external perspective to the research. In contrast, PVBA, a native of Bogotá with extensive research experience in Colombia among diverse population groups and research topics, contributed a localised interpretation likely influenced by their lived experience in Bogotá. While these perspectives enriched the analysis, they also reflect the subjectivity inherent in LE and PVBA's roles as researchers.

6.4. Results

A total of 26 students from grades 5, 6, and 7 participated in three focus groups. Most adolescents identified as male (59%) and were aged between 11 to 15 years (M=12.7 years; SD=1.2). A total of 10 teachers participated, with 3 opting for interviews and 7 completing the online survey. Among these teachers, 8 were from the same school as the focus group participants, and two were from two other schools in Bogotá. The participants' teaching experience ranged from 8 to 28 years (M=19.9 years; SD=8.4).

6.4.1. Part 1: Student and teacher attitudes and perceptions towards alcohol use

Quantitative data from the teacher surveys and interviews revealed that all teachers (10/10; 100%) perceived that drinking alcohol was common among Colombian youth and that it co-occurs with other risk behaviours. More than half (6/9; 67%) perceived alcohol consumption patterns as similar across different geographical locations (cities vs rural areas), however, only 40% (4/10) perceived alcohol consumption patterns as similar across different socioeconomic status levels. Awareness of evidence-based alcohol prevention resources for young Colombians was limited (1/10; 10%), however, most teachers (8/10; 80%) reported a high likelihood of using such programs if available. Refer to Appendix 5.8 for further details.

Table 6.1 summarises the four key themes that were generated from the student focus group discussions and teacher interviews/surveys, revealing shared perspectives of the cultural significance of alcohol. Detailed insights available in Appendix 5.9. Socioeconomic status was identified as having a greater influence than geographical differences on the initiation age and type of alcohol consumed. Despite awareness of health impacts and risks, one teacher emphasised the low-risk perception of alcohol in Colombian society, especially among minors.

Table 6.1. Summary of key themes related to student and teacher attitudes and perceptions towards alcohol consumption among young Colombians

Theme	Description	Example Quote
Cultural significance of alcohol	Alcohol plays a prominent role in Colombian culture, often present in celebrations and gatherings. Early exposure is common, and may be viewed by parents as promoting responsible consumption.	'*Unfortunately, alcohol is part of Colombian culture, it's seen in any kind of gathering,…it's considered normal for children and teenagers to consume alcoholic beverages at family gatherings, with some saying it's better for them to get used to it.*' (Teacher 6)
Developmental stages and initiations	Alcohol consumption among young people is perceived as common. Initiation often occurs in family settings, with minimal geographical variations. Urban areas offer diverse alcoholic beverages, while rural areas have traditional drinks. Socioeconomic status influences onset age and type of alcohol consumed.	'*Alcohol consumption among young Colombians normally first occurs in family spaces,…[rather than] differences in consumption by geographical locations,…what changes in the socioeconomic strata is the type of liquor consumed, well children from low socioeconomic strata consume more beer or low-priced liquor, while those in higher socioeconomic strata consume higher quality and priced liquor.*' (Teacher 3)
Alcohol consumption influences and practices	Student-perceived motivations for alcohol consumption included depression, seeking independence, rebellion, and curiosity. Social modelling – witnessing adults and peer consume alcohol – influences experimentation with alcohol. Students and teachers discussed commonality of combining alcohol with substances including cocaine, cannabis, and cigarettes.	'*…you also see several young people, and it seems that the others inspire them to try that, and well, they seem to like it,…and they keep trying it.*' (Grade 6 focus group)
Health awareness and risk perception	Students perceived immediate risks when young people consume alcohol including violence. Grades 6 and 7 extend concerns to	'*…people's risk perception scales regarding how serious consuming alcohol is, it is inversely proportional. Among all drugs,*

	long-term dangers, including cancer. However, some teachers discussed a low-risk perception in Colombian society, especially among minors, attributed to family influence.	*alcohol has the lowest risk perception, around 10% or a little less. This high frequency of consumption, especially among minors, is often linked to family influence*.' (Teacher 1)

6.4.2. Part 2: Relatability and acceptability of OurFutures within the Bogotá context

Student and teacher data from focus groups and interviews/surveys provided in-depth insights on the acceptability of OurFutures within the Bogotá context, including its potential integration into alcohol prevention curriculum in Colombia. This information is described in the following six themes.

6.4.2.1. i) The unique landscape of alcohol prevention in Bogotá schools

Most teachers reported being unaware of evidence-based alcohol prevention courses for young people in Colombia. Although training based on evidence offered by external organisations such as the Health Department was mentioned, concerns were also expressed about existing programs funded by the alcohol industry and potential conflicts of interest.

> '*Based on evidence, I only know about this one. I also know about training offered by the Pan American Health Organization in Colombia, along with the Health Department of Bogotá.*' (Teacher 1)

Alcohol education approaches varied among teachers, with no standardised alcohol prevention curriculum in Colombian schools. Some teachers described delivering it based on their judgement, using resources they found online, or involving external psychologists. Conversely, others outlined a comprehensive curriculum starting in fifth grade, covering various dimensions related to alcohol.

> '*Schools provide information for prevention purposes, but the program depends on each institution.*' (Teacher 8)

> '*…two psychologists from the …Health Department come. They conduct group activities focused on the theme of prevention,…as a whole group intervention. The intervention involves dynamics, games, and discussions about the topic. In cases of*

specific instances of consumption, we refer them to [the hospital] for further assistance…' (Teacher 2)

'*…In our school, we start in the fifth grade, focusing on identifying protective factors, …We begin by talking about alcohol, touching on the risks at a physical and cerebral level…In the sixth grade, we delve a bit more into the social dimension, in the seventh grade, into the biological dimension, in the eighth grade, into the dimension of human relationships, and in the ninth grade, we integrate it more.*' (Teacher 1)

Teachers expressed readiness to adopt evidence-based alcohol prevention programs with their students if they were relatable, available, engaging, and effectively addressed negative effects of early alcohol consumption.

Turning to the acceptability of the *OurFutures Alcohol Module,* the results from both student and teacher questionnaire data indicated it was generally received positively, with most students (25/26; 96%) and teachers (8/9; 89%) rating the lesson they reviewed as good or very good. Additionally, students reported a strong liking for the storyline (25/26; 96%) and characters (25/26; 96%). Generally, teachers agreed (9/10; 90%) that the educational content within the *OurFutures Alcohol Module* is appropriate for Colombian youth, and that they would use this program with their students (8/10; 80%). Further details on student and teacher acceptability data can be found in Appendix 5.10 and Appendix 5.11.

Analysis of qualitative data (focus group and interview discussions, and open-text responses) supported findings from the questionnaires. Students generally rated the *OurFutures Alcohol Module* lesson highly stating they liked the story, and teachers generally endorsed the program, citing its preventive approach and potential to destigmatise discussions on alcohol.

'*I would use the proposed program as it allows us to approach the subject in a preventive way and would eliminate the taboo that exists to talk to students about the topic of alcohol consumption.*' (Teacher 3)

The positive feedback, however, was accompanied with recommendations for improvement, particularly in terms of cultural contextualisation (summarised in Table 6.2).

Table 6.2. Key recommendations from teachers and students to integrate and improve the *OurFutures Alcohol Module* for the Bogotá context

Theme	Recommendations
i) The unique landscape of alcohol prevention in Bogotá schools	The program must be relatable to young Colombians, engaging, and effectively address the negative impacts of early alcohol consumption to encourage teachers to use the program with their students.
ii) The language needs to be contextualised	Incorporate familiar and culturally relevant language. Avoid overly technical or refined language. Consider integrating jargon and using everyday language used by young Colombians.
iii) Aligning alcohol representation in *OurFutures* with Colombian context	Adjust the portrayal of alcoholic beverages to better resonate with Colombian culture. Substitute instances of characters drinking vodka with locally familiar drinks like "Aguardiente" and common beer brands.
iv) Narrative elements and character diversity	Enhance character representation and story elements to align with the Colombian context. Address concerns about the perceived affluence of existing characters. Modify scenes to include diverse and realistic characters, avoiding beauty stereotypes and unrealistic scenarios.
v) Educational content	Ensure the content's appropriateness for different age groups from different schools, as some situations may not be suitable for all students.
vi) Teachers appreciate the flexibility in delivery but call for improvements	Provide additional activities. Ensure platform efficiency and consider the inclusion of follow-up sessions, ongoing evaluation, and continuous support and feedback for students.

6.4.2.2. ii) The language needs to be contextualised

Teachers and students emphasised the importance of using familiar and culturally relevant language in *OurFutures*. While some teachers perceived the existing language as relatable, others felt it was occasionally too technical. Suggestions included incorporating jargon and changing alcohol-related terms to align with everyday language used by young Colombians.

> '*It is necessary to recognise and use vocabulary that is familiar to young Colombians.*' (Teacher 3)

> '*…here in Colombia, we say "trago," [equivalent to booze in English] "chorro," "aguardiente," nothing too refined or delicate when talking about alcohol…and I see that in the cartoons, there was a language that was either too technical or too refined…*' (Teacher 2)

'*It would be very important to have the Colombian accent, the physical appearance of the characters, and their names, also the fashion…*' (Grade 7 focus group)

Students proposed culturally relatable alternatives for character names, including "Sebastián" for Mike, "Valentina" for Jane, "Tomás" for Tom, "Sara" for Claire, and "David" for Dave. Moreover, they recommended integrating colloquial or Bogotán expressions to substitute words that may not resonate well with Colombian audiences. For instance, they identified the term "guay" ("cool" in English) as characteristic of Spanish from Spain, suggesting more typical Colombian expressions to replace it, including "chévere".

6.4.2.3. iii) Aligning alcohol representation in OurFutures with the Bogotá context

Students recommended aligning the depiction of alcoholic beverages in *OurFutures* with Colombian culture. Suggestions included swapping instances of characters drinking vodka with locally familiar drinks such as "Aguardiente" (brandy in English), premixed drinks, and common beer brands. Only grade 5 students discussed a preference for mixing beer with sweets, a trend they observed on TikTok.

'*There wouldn't be vodka, rather aguardiente…*' (Grade 7 focus group)

6.4.2.4. iv) Narrative elements and character diversity

Students and teachers expressed concerns regarding the misalignment of character representation and storyline elements within the Bogotá context. Despite appreciating some characters, students desired more characters and criticised the perceived affluence of existing ones. Recommendations included changes to clothing, hairstyles, and broader diversity in appearances to better represent people of their age.

'*They were very posh, I would change that.*' (Grade 5 focus group)

Teachers echoed the need for more realistic and diverse characters, expressing concerns about beauty stereotypes and relationship portrayals.

'*There were some little things that bothered me, I feel that there are some beauty stereotypes…the only one with a boyfriend in the group is the slim cute girl*.' (Teacher 1)

Both students and teachers suggested modifying beach scenes (more aligned with Australian contexts) to park environments to better resonate with youth in Bogotá. Students also critiqued a scene involving characters riding a shopping trolley as unrealistic, suggesting alternatives such as riding bikes. Teachers proposed including locations where young people consume alcohol such as family gatherings to better reflect social dynamics in Colombia. While some scenarios were praised by teachers, with one stating they appreciated *OurFutures'* effort in presenting realistic situations, others raised concerns, particularly regarding the portrayal of absent parents.

> '*…it somewhat contradicts what parents might expect. I think, while the situation, for example, about girls drinking, one's mother being absent, the context of absent parents—parents are absent, but not absent like that…*' (Teacher 1)

6.4.2.5. v) Educational content

Teachers generally appreciated the clarity and appropriateness of the content, and commended its diverse representation of authority figures extending beyond the police. This broad representation was perceived as an effective strategy to raise awareness about decision-making and social influence. However, one teacher perceived a lack of religious or spiritual elements, and others expressed concerns about the advanced content, deeming it inappropriate for certain age groups.

> '*Yes, the educational content, because it's a matter of raising awareness about decision-making…I found it interesting that they didn't only portray the police as [the only] authority figure…authority figures are also at home, parents, guardians, here at school, teachers, counsellors, coordinators…I consider that part of the pedagogical sense is very well framed.*' (Teacher 2)

> '*It is very advanced for the age of the children.*' (Teacher 9)

> '*…I'm also a homeroom teacher for seventh grade, ranging from 13 to 14 years old; it wouldn't work at all. The content is a bit advanced, and in terms of the situation, showing them that might open windows they're not ready for yet. They wouldn't understand the situations very well.*' (Teacher 1)

6.4.2.6. vi) Teachers appreciate the flexibility in delivery but call for improvements

Teachers expressed diverse perspectives on the *OurFutures* format. Some valued the 20-minute cartoons as the core component and flexibility in completing optional activities, deeming this format suitable for class schedules, especially when time constraints are a concern. Conversely, some called for additional activities, whereas others found the format lengthy and wanted more dynamic and engaging elements. The two teachers who reviewed *OurFutures* via the website said the platform was slow.

> '*…it was cool that the central part was 20 minutes, I think that's what you can take advantage of in a class. In my classes, they are 50 minutes long, and in the end, between discipline, behaviour issues, what ends up being used in a class is about 20 minutes,…doing more activities is a bit ambitious…*' (Teacher 1)

Other recommendations from teachers included incorporating follow-up sessions, continuing evaluation for enhanced learning outcomes, and providing ongoing support and feedback.

> '*Follow-up and not abandoning the program.*' (Teacher 4)

> '*Feedback and ongoing evaluation*.' (Teacher 5)

6.5. Discussion

This study formatively assessed the acceptability of one lesson from the *OurFutures Alcohol Module* in the Bogotá context, as well as participant attitudes and perspectives underpinning alcohol consumption among young Colombians to better understand how to guide the adaptation of the program. By gathering insights from Colombian young people and teachers, this study represents the initial step towards informing the adaptation of an effective eHealth school-based program for the Bogotá context. Feedback from 26 students in three focus groups and ten teachers through surveys (7 teachers) and interviews (3 teachers) highlighted the significant impact of cultural and social factors on attitudes toward alcohol among young Colombians. It underscored the importance of programs such as the *OurFutures Alcohol Module* in their context. While overall participants found the *OurFutures Alcohol Module* lesson acceptable and provided positive feedback about the program, several recommendations were made to enhance its cultural relevance. This emphasises the need for

refinements based on participant feedback to ensure optimal effectiveness and resonance within the Bogotá context.

A prevalent theme was the cultural significance of alcohol in Colombian society, with participants discussing its ubiquitous presence in celebrations and gatherings, synonymous with social enjoyment. Participants collectively acknowledged these events as early and normalised exposures for young Colombians. Thus, the consensus among participants on the commonality of alcohol consumption among young Colombians was unsurprising, and also aligned with the 2019 ENCSPA Colombian National Survey findings (National Administrative Department of Statistics. DANE, 2020). Teachers also perceived that geographical and socioeconomic factors influence adolescents' alcohol preferences, however, emphasised the added impact of socioeconomic status on alcohol initiation among young Colombians. This underscores the importance of universal alcohol prevention interventions portraying variations in alcoholic beverages for relevance in both urban and rural areas, and across socioeconomic status levels. Furthermore, offering earlier program delivery is crucial, particularly due to the earlier age of first alcohol use in Colombia compared to Australia (National Administrative Department of Statistics. DANE, 2020).

The *OurFutures Alcohol Module* is well-suited to address these issues, employing a harm minimisation and social influence approach, coupled with attributes associated with positive prevention outcomes (Ogden & Hagen, 2019; UNODC/WHO, 2018). This approach involves providing evidence-based information about alcohol use and associated harms, normative education to correct misperceptions, and resistance skills training. As students cited various motivations for alcohol consumption, ranging from curiosity, seeking independence, and social modelling, where young people imitate the alcohol-related behaviours observed in adults and peers (which is consistent with Yuen et al. (2020) findings on peer influence in alcohol use), *OurFutures*' focus on social influence aligns with the experiences articulated by students. Furthermore, *OurFutures* aligns with the 2019 Colombian Comprehensive Policy for Psychoactive Substance Use, which advocates for capacity building within educational communities, strengthening coping skills to resist social pressures related to substance use and supporting the implementation of evidence-based harm reduction strategies (Ministry of Health and Social Protection, 2019).

Teachers discussed the unique landscape of alcohol prevention in Colombian schools, noting a lack of standardised alcohol prevention curricula with varying approaches among them for implementing such education, and limited teacher awareness of evidence-based resources (10%). Most teachers (80%) expressed a high likelihood of using a tailored digital alcohol education program, contingent on relatability, availability, and engagement. Together these observations highlight the imperative of tailoring the *OurFutures Alcohol Module* to the Bogotá context, particularly as most teachers were unaware of evidence-based programs and some of the only programs teachers referenced were funded by the alcohol industry, which have been reported as problematic for minors (Robaina et al., 2020).

Student focus group and teacher interview/survey insights into the relatability and acceptability of *OurFutures* within the Bogotá context, demonstrated that overall, *OurFutures* was rated positively, with 96% of students and 89% of teachers rating the lesson highly. Additionally, 96% of students liked the storyline and characters. Most teachers (90%) perceived the content as reasonable and showed a willingness to deliver the program with their students (80%). Both groups identified key areas for improvement, which the research team will address through a detailed, iterative, co-design process, including language contextualisation, adjusting depiction of alcoholic beverages to align with Colombian culture, incorporating diverse and realistic characters, modifying narrative elements, adjusting educational content for different age groups, and refining the program format.

Regarding language contextualisation, teachers and students stressed the importance of using familiar, colloquial vocabulary and culturally relevant expressions. This includes adjusting alcohol-related terms to match everyday language used by young Colombians, updating character names with culturally relevant alternatives, and integrating colloquial expressions to replace terms that may not have translated well or reflected vocabulary from Spain rather than Colombia. Given the variation in Spanish lexicon between Colombia and Spain (Ardila, 2020), accurate and culturally appropriate language use is essential. Thus, a meticulous language adaptation process, such as the one outlined by Maríñez-Lora et al. (2016) that involves not only forward translation, but also back-translation and harmonising the translation to confirm it reflects the original meaning is warranted.

Both students and teachers highlighted the misalignment of character representation and story elements with the Bogotá context, seeking more realistic and diverse characters, critiquing

the perceived affluence of existing ones and suggesting changes to clothing, hairstyles, and broader diversity. As feedback was gathered from public school students, the affluence concern may not apply to students from schools in more affluent areas of Bogotá. Nevertheless, to address these considerations, a collaborative approach involving the co-design of new characters with youth in Bogotá is necessary to ensure authenticity and relevance. Modifying unrealistic scenes was perceived as important by both groups to ensure cultural relevance, with recommendations including shifting from beach to park environments, – considering Bogotá's landlocked nature – and including family gatherings as settings for alcohol consumption among youth in Bogotá, aligning with participants' views on the cultural normalisation of alcohol in such situations. Teachers additionally expressed concerns about beauty stereotypes and relationship depictions, which are crucial to address in the cartoons. Adolescence is a formative period where individuals are developing their identities and self-perceptions (Ogden & Hagen, 2019). Adolescent exposure to unrealistic beauty standards can contribute to body image issues and negatively impact self-esteem and mental health (McBride et al., 2019). Diverse portrayals of relationships can influence adolescents' understanding of healthy relationships, fostering positive social dynamics and interpersonal skills (Taba et al., 2020; Vaterlaus et al., 2018; West et al., 2021). Therefore, it is essential to address these concerns through co-design with youth in Bogotá, so that the content remains engaging and relevant, ultimately promoting adolescents' overall wellbeing.

Teachers typically appreciated the educational content's clarity and appropriateness, especially the inclusion of various authority figures beyond police, encompassing parents, teachers, and counsellors, which is characteristic of the comprehensive approach adopted in *OurFutures*. Concerns raised by a teacher about the inappropriateness of the advanced content for certain age groups suggest comprehensive content testing with school students from diverse backgrounds to align with students' developmental stages is required. This ensures relevance without compromising educational integrity, as delivering the program at a later age would not precede the average onset of alcohol consumption in Colombia. Although careful consideration of the appropriateness of the content for younger age groups is warranted. Teacher feedback on the *OurFutures* format varied, with some valuing the 20-minute cartoons and flexibility, while others finding it lengthy and desiring more dynamism. As most teachers reviewed the PDF version of the cartoons, it is challenging to gauge whether their opinions would remain consistent when viewing the cartoons on the website. Although the website was not without issue as two teachers expressed concerns about the

poor platform speed, emphasising the need for optimised website performance outside of Australia. Additional recommendations included follow-up sessions, continuous evaluation, and ongoing support for enhanced learning outcomes.

6.5.1. Limitations & Strengths

It is crucial to interpret the study findings within the context of certain limitations. Despite Bogotá being the most populous and largest city in Colombia, the study findings may not fully capture the country's regional diversity. Furthermore, the involvement of only one public school for the focus groups may limit representation of the diverse student population both in Bogotá and across Colombia. However, it was important to collaborate with this school as it served disadvantaged adolescents, offering a unique opportunity to offer essential resources to support the needs of this underserved population. A key strength of *OurFutures* is that it is built on complex models of behaviour change which are embedded within the storylines of the cartoons to engage and maintain student interest and involvement, with significant intervention effects in Australia (Newton et al., 2020; Newton et al., 2022; Slade et al., 2020). However, as the applicability of the behaviour change principles underpinning *OurFutures* in the Bogotá context was not explored in the current study, the next phase of program adaptation could assess these principles' relevance in a cross-cultural context and examine the contextual nuances influencing behaviour change outcomes in educational settings. Additionally, while this study focused on reviewing one lesson from the *OurFutures Alcohol Module*, which was sufficient for the purposes of the current study—intended as the first step in guiding the adaptation of the *OurFutures Alcohol Module* to the Bogotá context—future research should involve testing the entire module with young Colombians and teachers to gain a broader understanding of its effectiveness, cultural adaptability and potential impact in the Bogotá context. Despite certain limitations, the use of quantitative and qualitative data in this study aided in contextualising and strengthening the findings for a better understanding of the cultural adaptation of the *OurFutures* program within the Bogotá context. Additionally, this study, through the collection of valuable feedback from Bogotá youth and teachers, serves as an essential step towards informing the adaptation of an effective eHealth school-based alcohol prevention program for the Bogotá context. Such a program is currently non-existent, yet critical, particularly considering the absence of standardised alcohol prevention education in Colombia. Moving forward, additional consultations with students and teachers will be conducted to further refine and enhance the program.

6.5.2. Conclusion

This study marks the first step in informing the adaptation of an effective eHealth alcohol prevention program to the Bogotá context by gathering feedback from young Colombians and teachers. The implications of the study extend to the broader field of alcohol prevention in Colombian schools, with the identified challenges and recommendations providing valuable insights for developing culturally tailored preventive interventions. The findings provide evidence that the *OurFutures Alcohol Module* could be an acceptable and engaging alcohol prevention strategy in the Bogotá context, once appropriately adapted. The next steps involve incorporating participant feedback into the iterative adaptation of the OurFutures program, ensuring its relevance in the Bogotá context, and evaluating the feasibility of the program. Collaboration with place-based end-users, ongoing evaluation and a commitment to cultural sensitivity will be crucial in shaping a sustainable and impactful alcohol prevention initiative for young Colombians.

Chapter 7

General discussion

The global prevalence and burden of chronic disease disproportionately affects disadvantaged populations, including those of low SES and those living in geographically remote ('regional', 'rural', and 'remote') contexts. These health inequities are systemic, unjust and avoidable (McCartney et al., 2019). Adolescence creates a blueprint for future health behaviours and outcomes, thus presenting a pivotal window of opportunity to alleviate future chronic disease burden and exacerbated inequities. During adolescence, lifestyle risk behaviours such as poor diet, alcohol use, tobacco smoking and vaping typically emerge. Indicators of poor dietary habits, such as insufficient fruit and vegetable intake and excessive consumption of SSBs and discretionary foods, tend to increase with age. Furthermore, the peak onset for initial use of alcohol, tobacco smoking, and vaping, is generally between 13.9 years (e.g. in Colombia (National Administrative Department of Statistics. DANE, 2020) through to 16 years (e.g. in Australia (Australian Institute of Health and Welfare, 2020d), although there is some variation between countries. Therefore, this is a critical stage of life to intervene with evidence-based prevention approaches. Such approaches should aim to halt, or at the very least, significantly limit: (a) entrenchment of these risk behaviours; (b) their progression into adulthood; and (c) the widening health equity gap experienced by disadvantaged populations.

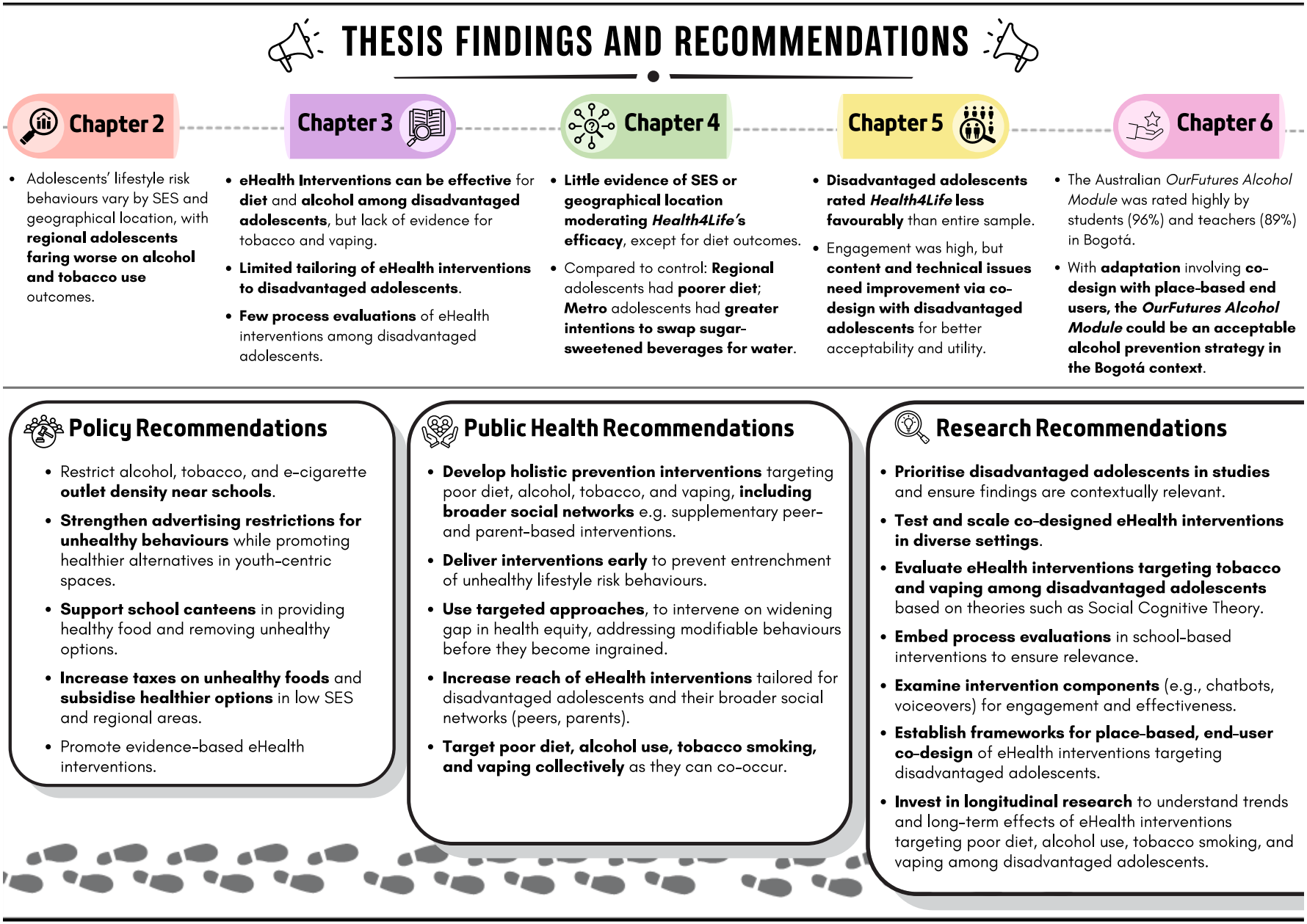
The overall aim of this thesis was to address key evidence gaps (outlined in Chapter 1, Table 1) about chronic disease risk behaviours among adolescents from low SES and geographically remote contexts – with a primary focus on adolescents in Australia. More broadly, this thesis provides new insights and strategies contributing to the global evidence base, that informs both effective and equitable lifestyle behaviour interventions. Specifically, this thesis aimed to:

1. Identify the prevalence and patterns of poor diet, alcohol use, tobacco smoking and vaping across different sociodemographic adolescent groups in Australia, with comparisons between adolescents classified as:
    a. disadvantaged (low SES and/or living regionally) and more advantaged (mid to high SES and/or living in metropolitan areas),

   b. across different SES levels (low, mid, and high),
   c. and geographical locations (regional compared to metropolitan adolescents).
2. Systematically review the efficacy of eHealth interventions targeting adolescents from disadvantaged contexts in preventing poor diet, alcohol use, tobacco smoking, and vaping.
3. Examine the influence of SES and geographical location on the efficacy of the universal school-based *Health4Life* intervention in reducing alcohol and tobacco use, improving dietary habits, knowledge of chronic disease risk behaviours, behavioural intentions and reducing psychological distress.
4. Investigate the implementation and relevance of the universal school-based *Health4Life* intervention among disadvantaged adolescents in Australia.
5. Assess the acceptability and potential global scalability of an effective eHealth school-based alcohol use prevention program, the *OurFutures Alcohol Module*, among disadvantaged adolescents overseas such as Bogotá, Colombia.

This thesis makes a significant and novel contribution to the field of adolescent health and chronic disease prevention, by examining the intersection of SES, geographical location and lifestyle risk behaviours such as poor diet, alcohol use, tobacco smoking, and vaping among adolescents. The findings significantly advance our understanding of these critical issues and postulate actionable insights, thereby providing a global perspective for intervention design, implementation and scalability. Methodologically, this thesis applied rigorous and sophisticated cross-sectional (Chapters 2, 5) and longitudinal analyses of clustered randomised controlled trial data (Chapter 4); synthesised the evidence for eHealth interventions among disadvantaged adolescents globally (Chapter 3); and demonstrated the acceptability and feasibility of eHealth interventions in diverse contexts – nationally and internationally (Chapters 5, 6). Collectively, the findings point to the importance of early, effective, and acceptable prevention strategies in adolescence, that not only address the health equity gap, but also provide a pathway for improving both individual outcomes and broader public health. Figure 7.1 summarises the key findings, implications and recommendations from this thesis. This final chapter will discuss these in detail, by first summarising the overall findings of this thesis (Section 7.1); followed by the strengths and limitations identified (Section 7.2); the implications of these findings, alongside recommendations for future research (Section 7.3); and finally, the overall conclusions from this body of work (Section 7.4).

Figure 7.1. Summary of thesis findings, implications, and recommendations



7.1. Overview of findings

7.1.1. Knowledge Gap 1: Current prevalence and co-occurrence of poor diet, alcohol use, tobacco smoking, and vaping among diverse sociodemographic adolescent groups in Australia

This thesis addressed a notable gap in the Australian evidence base, regarding the current prevalence and co-occurrence of lifestyle risk behaviours among diverse sociodemographic groups, namely, poor diet, alcohol use, tobacco smoking, and vaping. As previously mentioned, much of the existing evidence on this topic is (a) outdated; (b) only considers these lifestyle risk behaviours in isolation, rather than their co-occurrence among the same study sample; (c) focuses on younger cohorts, prior to the typical onset of tobacco and alcohol use; (d) lacks information on vaping; and/or (e) has not controlled for key covariates, such as: gender and psychological distress.

Chapter 2 addressed these limitations by conducting a cross-sectional analysis of these risk behaviours among a large and geographically diverse sample of 4,445 Australian adolescents aged 14-17 years in 2022, adjusting for gender and psychological distress. The findings reported a nuanced and complex picture of these behaviours, finding that there are no uniform patterns of these behaviours across SES and geographical locations. Specifically, adolescents of lower SES demonstrated a 13% lower prevalence of excessive discretionary food consumption, a 22% lower prevalence of consuming a full alcoholic standard drink, and a 32% lower prevalence of binge drinking, compared to mid-to-high SES adolescents in the sample. In contrast, adolescents living in regional areas displayed a 41% higher prevalence of consuming a full alcoholic standard drink, 77% higher prevalence of binge drinking, and double the prevalence of tobacco smoking, compared to those living in major cities. This suggests that current prevention approaches may not be effectively reaching, and/or be adequate for regional adolescents. These findings indicate that tailored prevention efforts by SES and geographic location may be needed. To build upon this work and further understand the nuances between sociodemographic factors and poor diet, alcohol use, tobacco smoking, and vaping, longitudinal research is needed to track these behaviours over time among representative samples.

7.1.2. Knowledge Gap 2: Generating evidence about the efficacy of eHealth preventative interventions for disadvantaged youth

This thesis addressed a critical gap in the Australian and global evidence base on the efficacy of eHealth preventative interventions for adolescents from low SES and geographically remote contexts, and empirically explored the influence of SES and geographical factors on eHealth intervention outcomes and implementation.

Notably, **Chapter 3** represents the first study to systematically synthesise the evidence on eHealth interventions targeting adolescents of low SES and/or living in geographically remote contexts, in preventing poor diet, alcohol use, tobacco smoking, and vaping. The review revealed that most interventions focus on low SES adolescents, with limited studies focusing on adolescents from geographically remote areas, and only one included study targeted adolescents of both low SES and geographically remote contexts. Studies were predominantly aimed at improving dietary habits, with fewer studies targeting alcohol and tobacco use, and none targeting vaping. Among the 14 interventions reviewed, only five demonstrated significant intervention effects on diet and alcohol outcomes. Specifically, increasing fruit and vegetable intake, reducing SSB and discretionary food consumption, and reducing binge drinking. Effective dietary interventions were underpinned by Social Cognitive Theory, and incorporated personalised feedback to participants, while effective alcohol interventions were guided by the I-Change Model, and also included personalised messaging or feedback. The lack of effective interventions targeting tobacco use and vaping among disadvantaged adolescents identifies this as a key area for future research. Furthermore, this review highlighted the limited tailoring of eHealth interventions specifically for disadvantaged adolescents. This represents a missed opportunity to meaningfully improve chronic disease risk profiles of disadvantaged adolescents – especially considering the growing evidence supporting the effectiveness of universal eHealth interventions for lifestyle risk behaviours (A. Hutton et al., 2020; Kazemi et al., 2021; Kemp et al., 2021; Taylor et al., 2017).

Chapter 3 also demonstrates the potential of eHealth interventions to prevent key lifestyle risk behaviours among disadvantaged adolescents; and provides valuable insights into the components of effective interventions – such as behaviour change theories for specific health behaviours, and personalised feedback. Despite the remaining challenges in developing, delivering, and disseminating findings on effective evidence-based programs for the prevention of chronic diseases among disadvantaged adolescents, the findings from this review offer crucial guidance for future interventions.

Building on the findings of **Chapter 3,** which highlighted the paucity of eHealth interventions designed for disadvantaged adolescents – and even fewer that are effective, **Chapter 4** evaluated the influence of SES and geographical location, on the universal school-based *Health4Life* intervention. Using data from the large, multi-site *Health4Life* cluster RCT (n=6,639, 71 schools), **Chapter 4** primarily focused on behaviour change outcomes related to poor diet, alcohol use, and tobacco smoking, alongside secondary outcomes including behavioural intentions (diet-, alcohol-, and tobacco-related), psychological distress and knowledge of lifestyle risk behaviours, over 24-months (2019-2022). Results showed there was generally little evidence that SES or geographical location moderated *Health4Life*'s effects on most outcomes. The key exception was diet-related outcomes, which varied significantly by geographical location. Specifically, adolescents in major cities in the *Health4Life* group demonstrated greater intentions to swap SSBs for water, compared to the control group. Whereas adolescents in regional areas in the *Health4Life* group were more likely to report poor diet outcomes, than those in the control group. Several important conclusions can be made from these findings. Firstly, *Health4Life* maintained a positive impact on adolescents' knowledge of chronic disease risk behaviours, potentially due to other factors, such as: personal motivation or learning styles. Secondly, despite no moderation effect on alcohol and tobacco outcomes, these behaviours may be affected by individual or contextual factors, such as: family dynamics and social support. This presents a latent opportunity for deployment of a tailored *Health4Life* intervention, focussed on achieving greater behavioural change impact in such contexts. Thirdly, despite *Health4Life* having a positive intervention effect on adolescents' intentions to swap SSBs for water, study results did not provide evidence of improved diet outcomes for adolescents living in major cities. This suggests that greater attention to mitigating external influences – including peer pressure affecting dietary choices (Ragelienė & Grønhøj, 2020) and socio-cultural factors (for example, high advertising of unhealthy foods in major cities (Richmond et al., 2020; Sainsbury et al., 2017)), is needed to facilitate this behavioural change.

A key takeaway from this study is the need for further investigation into the unexpected effect of *Health4Life* on regional adolescents' diet outcomes. Future studies should: (a) collect information on school policies influencing diet (e.g. canteen and other health promotion policies); (b) use matched sampling methods, to ensure that the control and intervention schools do not drastically differ in the amount of standard health education they deliver; and (c) explore implementation contexts via process evaluations, to provide additional information to understand unexpected findings.

Notwithstanding, these findings point to the need for co-designing an adapted version of *Health4Life*, specifically for regional adolescents.

7.1.3. Knowledge Gap 3: Acceptability, fidelity, and feasibility of universal evidence-based, school-based digital interventions, for disadvantaged youth in Australia and Colombia

This thesis filled a notable gap in the evidence base regarding the acceptability, fidelity, and feasibility of universal school-based digital interventions for disadvantaged adolescents in Australia, and their applicability in Colombia. The findings from **Chapter 3** highlighted that few studies have reported on the implementation of school-based digital interventions targeting poor diet, alcohol use, and tobacco smoking, among disadvantaged adolescents. Most particularly, there was a paucity of formal process evaluations of interventions for disadvantaged adolescents, including both: students – as end-users; and teachers – who play a key role in school-based intervention implementation. **Chapter 5** addressed this gap, by analysing process evaluation outcomes of the universal *Health4Life* intervention among a subset of disadvantaged adolescents and their teachers. **Chapter 6** then built on these findings, to demonstrate the acceptability and feasibility of eHealth interventions in diverse contexts internationally.

7.1.3.1. Health4Life process evaluation among disadvantaged adolescents and their teachers

Chapter 5 examined the implementation context of the *Health4Life* cluster RCT among low SES and regional students. Findings demonstrated that disadvantaged adolescents rated *Health4Life* less favourably than the entire sample (66% versus 75%): reporting lower enjoyment of the stories (63% versus 75%); and fewer in this cohort planning to use the skills and information in the future (60% versus 70%). In contrast, teachers in the subsample evaluated *Health4Life* positively, consistent with the entire sample – indicating the perceived value of *Health4Life* by this subsample of teachers in low SES and regional contexts. Despite these mixed findings, analysis of the implementation data showed teachers from low SES and regional schools perceived student engagement to be higher than in the entire sample (~92% versus ~85%). This study highlighted areas for refinement, and the critical step of co-designing an adaptation of *Health4Life* with disadvantaged students and their teachers, to

improve its relevance and subsequent effectiveness for them. Ultimately, these findings suggest that, with appropriate adaptation and optimisation to address the specific needs of disadvantaged adolescents, universal school-based interventions, such as *Health4Life*, could be acceptable among these populations.

7.1.3.2. Global acceptability of Australian OurFutures Alcohol Module and potential scalability

Chapter 6 extended the insights from **Chapter 5**, by assessing the global scalability and acceptability of the effective universal school-based eHealth intervention, *OurFutures Alcohol Module,* originally developed in Australia, in an international context of Bogotá, Colombia. The study reported high satisfaction with the program among students (96%) and teachers (89%), and identified recommendations from participants regarding areas for improvements, including: contextualising the content (e.g. names, scenarios, character names, clothing, language) to increase its relatability. Overall, the results of this study highlighted the importance of culturally adapting and tailoring interventions for local contexts to facilitate increased engagement and usability among end-users.

The study contributes significantly to the literature, by providing evidence to support place-based, end-user involvement in co-designing the adaptation of prevention programs, such as the *OurFutures Alcohol Module.* This study was the crucial first step in developing a new evidence-based alcohol prevention strategy for the Bogotá context. These findings are particularly impactful given that Colombia currently lacks standardised alcohol prevention in schools – despite early initiation of alcohol use among adolescents (National Administrative Department of Statistics. DANE, 2020). Thus, a program such as *OurFutures* is urgently needed. Future iterations of the program will need to be expanded and adapted to other regions of Colombia – including assessment of the feasibility and efficacy of the intervention, in diverse local contexts.

7.2. Strengths and limitations of the research

7.2.1. General strengths

Key strengths for **Chapters 2** and **4** are their analysis of lifestyle risk behaviours in large, geographically diverse adolescent samples (n=4445 for **Chapter 2** and n=6639 for **Chapter**

4), thereby increasing the robustness of study findings. **Chapter 2** provided a key update to the current evidence base, which delivered a comprehensive comparison of the prevalence of poor diet, alcohol use, tobacco smoking, and vaping outcomes in Australia, across diverse sociodemographic groups (i.e. comparing varying levels of SES; geographical locations; and the combination of SES and geographical locations) – adjusting for key covariates, which are often unadjusted for in other analyses. **Chapter 2** provided key insights into prevention approaches to address disparities in these outcomes across SES and geographical locations. **Chapters 3, 4** and **5** further advance the field of public health by applying innovative and distinct approaches to evaluating eHealth interventions among disadvantaged adolescents. For instance, **Chapter 3** systematically synthesised existing evidence and also identified the dearth of published research on this topic. This provided a rigorous update and analysis of components present in effective interventions and actionable recommendations for future interventions among disadvantaged adolescents. **Chapter 4** applied sophisticated statistical analysis methods to evaluate the influence of SES and geographical location on *Health4Life*'s efficacy on behaviour change over 24-months. **Chapter 5** provided further insights into differences reported in the outcomes of **Chapter 4** by conducting a process evaluation of *Health4Life* among a subsample of 214 disadvantaged students and their teachers. This afforded new insights that few recent evaluations have explored. It also generated practical implications for interventions among diverse sociodemographic adolescent contexts in Australia. Finally, **Chapter 6** provided crucial insights into the potential scalability and acceptability of the effective *OurFutures Alcohol Module* in international contexts, namely the Bogotá community in Colombia, by collecting data from both students and teachers. The data collected was crucial to informing adaptation of the *OurFutures* program to the Bogotá context; and therefore, marks an essential first step in this adaptation process.

7.2.2. General limitations

There are several limitations of this research that warrant consideration. In terms of sample representativeness, **Chapters 2** and **4** included predominantly affluent and major city-located adolescents – limiting the generalisability of findings to all disadvantaged adolescents in Australia. For **Chapter 5**, the subsample was predominantly from one state in Australia (NSW), and only 58% (n=214) of eligible adolescents, and 64% (n=16) of eligible teachers, provided process evaluation data. Thus, the sample may be skewed to more motivated participants – with possible non-capture of important insights into barriers to implementation

and acceptability, for other participants. **Chapter 6** focused on a single school in Bogotá, limiting the study findings' generalisability to the broader adolescent population within Bogotá, and across Colombia's diverse regions. **Chapter 3** excluded any interventions framed as treatment rather than prevention, and thus, may have missed interventions for disadvantaged adolescents at greater risk: for example, early interventions for alcohol use disorder.

The literature review search for **Chapter 3** was conducted in 2022, and thus, may have missed more recently published studies, particularly those targeting vaping – a rapidly evolving area of research. Moreover, measurement challenges, including the reliance on self-report data for **Chapters 2, 4, 5**, and **6** may have introduced response bias across these studies, with participants reporting more 'favourable' responses in line with social desirability bias. For **Chapter 4**, the composite diet risk variable may have overlooked nuances in diet outcomes, and the variable to measure changes in diet intentions only focused on swapping SSBs for water, thus missing intentions for other diet components, such as: swapping discretionary food consumption for fruit and vegetables. Lastly, in **Chapter 6**, the behavioural change theories underpinning the *OurFutures Alcohol Module* were not assessed in the Bogotá context – preventing understanding of their cross-cultural applicability.

7.3. Implications and future directions

The main conclusions from this thesis and the implications of these findings are summarised in Figure 7.1. Below are detailed descriptions of each for three key stakeholders: policy, public health and prevention, and future directions for researchers.

7.3.1. Policy

7.3.1.1. Structural and legislative changes

As each of the studies from this thesis has emphasised, disadvantaged populations that include low SES and regional adolescents, tend to experience disproportionate chronic disease burden, when compared to their more advantaged counterparts. Due to the unique structural, economic, and social barriers they experience in relation to better health outcomes, they may lack the autonomy or resources to have control over their health choices. As such,

structural supports – including legislative and regulatory measures – are critical in facilitating an environment conducive to healthier choices.

As reported in **Chapter 2,** regional adolescents demonstrated a significantly higher prevalence of alcohol (i.e. full standard drink and binge drinking) and tobacco-related behaviours, than adolescents in major cities. Similarly, when examining dietary habits in **Chapter 4**, regional adolescents in the *Health4Life* intervention group had significantly poorer dietary outcomes than regional adolescents in the control group, pointing to demand for a tailored legislative changes approach, proportionate to circumstantial needs. Despite **Chapter 2** demonstrating that lower SES adolescents reported significantly better outcomes than their more advantaged counterparts – in terms of consuming less discretionary foods and alcohol (i.e. full standard and binge drinking) – as previously mentioned, the sample was predominantly of high affluence. Thus, the experiences of low SES adolescents may have been under-represented.

Nevertheless, structural inequities contribute to and perpetuate lifestyle risk behaviour disparities among disadvantaged adolescents. This includes greater exposure to unhealthy food environments, with affordable and healthy food less attainable. For example, higher exposure to fast-food outlets (Trapp et al., 2022), and advertisements for discretionary food items near schools in low SES than high SES areas, have been reported (Wells et al., 2023). Moreover, marketing near schools is more likely to show unhealthy food and alcohol advertisements, while least likely to advertise fruits and vegetables (Wells et al., 2023). Regional adolescents may also be exposed to greater pro-tobacco advertising (Pesko and Robarts, 2017), and a higher outlet density of stores selling e-cigarettes near secondary schools in regional Australia, which is a risk factor for e-cigarette use (Tuson et al., 2024). These exposures may facilitate environments where unhealthy foods, alcohol, tobacco smoking, and vaping are more socially accepted and normalised, than healthier behaviours. Indeed, this aligns with the rationale proposed by Castro, Haug, Wenger and Schaub (2022), who suggested that the social acceptance of alcohol may have made it harder to change in their MHBC intervention, despite participants acknowledging alcohol as unhealthy.

With this in mind, the following structural and legislative policy recommendations are proposed to support disadvantaged adolescent populations: (1) implementing greater restriction of alcohol-, tobacco-, and e-cigarette-related shop density near schools; (2) strengthening advertising restrictions to limit exposure to SSBs, discretionary foods, alcohol, tobacco and vaping products, whilst simultaneously promoting healthier alternatives, such as:

fruit and vegetables; (3) increasing taxes on SSBs and discretionary foods, and providing subsidies to reduce the cost of healthy foods in low SES and regional areas; and (4) offer incentives for food producers and retailers to supply healthier options, specifically in low SES and regional areas – where higher costs and limited access of healthier options, are a huge barrier for low SES and regional populations.

7.3.1.2. Accessibility to healthier foods and reducing exposure to unhealthy risk factors

One key area to improve the nutritional quality and content of options available for low SES and regional adolescents is via school canteens. Research has found that Australian canteens in low SES areas are more likely to sell SSBs, than those in high SES areas (Haynes et al., 2020). Moreover, Australian school canteen adherence to national healthy eating guidelines is typically poor (Lucas et al., 2017). To address this, supporting schools in low SES and regional areas to prioritise offering nutritious food at school canteens is needed. Strategies may include government-funded nutritious school meals, similar to Sweden's universal approach, which ensures all students aged 6-16 years receive healthy meals (Lucas et al., 2017). Alternatively, Australian government bodies should take stronger action by encouraging schools to remove unhealthy options entirely from canteens, pricing them significantly higher than healthier options, or providing free fruit and vegetables. Providing free fruit and vegetables in low SES schools in Australia has been found to significantly increase students' consumption of these foods (Hector et al., 2017). Efforts at home are equally important to reinforce healthier dietary habits. Compared to their high SES counterparts, low SES adolescents often have greater access to SSBs at home (Hardy et al., 2016). They are also more likely to be rewarded with sweets, which devalues their preference for healthier food including fruit and vegetables (Hardy & King, 2012).

Affordability of healthier options compared to unhealthier options, particularly SSBs plays a pivotal role in disadvantaged adolescents' food consumption behaviours. Limited budgets may lead to some low SES parents avoiding purchasing foods their children dislike, in order to mitigate food waste (de Brito et al., 2024). However, this can subsequently hinder the development of healthy eating habits. Subsidies for healthier options, and support for families in low SES and regional areas to adopt healthier dietary habits, are crucial to facilitating behaviour change across school and home environments (Lee et al., 2021). This is particularly important considering that in 2022, the World Bank reported that 3.2% of the

Australian population (1 million people) could not afford a healthy diet – which rose from 2.9% in 2017 (World Bank Group, 2024).

Reducing disadvantaged adolescents' exposure to alcohol, tobacco, and vaping, requires targeted advertising bans in youth-centric environments: including schools; public transport (e.g. bus and train stands); entertainment venues – such as cinemas; and digital spaces – such as gaming, social media, and streaming platforms (Bain et al., 2023; Donaldson et al., 2022; Jancey et al., 2024). While ambitious, policies such as New Zealand's proposal to ban cigarette sales to future generations – which was overruled earlier this year – may not yet be feasible, for political and societal reasons (Andrew, 2024), they offer a promising long-term strategy for reducing exposure to tobacco, which is a leading, yet preventable risk factor, for death and disability (GBD 2019 Risk Factors Collaborators, 2020).

Health promotion campaigns, including on digital platforms, are key to complementing these strategies, and counteracting exposure to unhealthy influences. Notable examples include the New South Wales Government's *Do you know what you're vaping?* (2022-2023) campaign, which delivered 14-17-year-olds information about the chemicals in vaping products (Trigg et al., 2023). Additionally, the Western Australian Government's *LiveLighter* (2013-2018) campaign, which aimed to improve dietary habits among adults aged 25-64 years, showed promise in reducing SSB consumption among adolescents (Gascoyne et al., 2023). While disadvantaged adolescents may be hard to reach at times, the benefit of digital campaigns is that they can be tailored to disadvantaged adolescents, and leverage platforms they are already engaged in.

7.3.1.3. Investing in education and harm minimisation messaging, particularly for those at risk

Strengthening parental engagement policies is an important area to target for reducing disadvantaged adolescents' engagement in unhealthy behaviours. For instance, parental attitudes towards SSBs are key factors affecting adolescents' SSB consumption (Pettigrew et al., 2015). Research among regional adolescents, for example, indicates they are more likely to acquire alcohol from their parents, and face less parental disapproval for alcohol use, than adolescents in major cities (Chan et al., 2016; Chan et al., 2015). Thus, higher alcohol consumption is accepted. Moreover, findings from Australia and internationally have reported that low SES adolescents are more price-sensitive to tobacco cigarettes, than high SES

adolescents (Brown et al., 2014); and are more likely to access tobacco via informal means (e.g. family members) (West et al., 2007). In contrast, high SES adolescents are more likely to access tobacco via formal means (i.e. via tobacco retailers). Community- and strengths-based approaches, rather than punitive measures, are needed to address such behaviours, without exacerbating existing disadvantages. One potential strategy is, subsidised or free, parent workshops in low SES and regional areas. These workshops could offer: (a) information on the risks of poor diet, alcohol use, tobacco smoking, and vaping; and the role of parental behaviour in influencing adolescent behaviour; (b) skills training to help parents constructively communicate disapproval of unhealthy behaviours, while encouraging healthier behaviours; and (c) a platform for parents with similar backgrounds to share experiences, and learn from each other, on promoting healthier behaviours among adolescents. These workshops could be led by university research groups, in collaboration with schools or community-based organisations, such as local drug action teams (LDATs), or community drug action teams (CDATs). Depending on local resources and needs, these workshops could be delivered in-person or online.

Turning to the adolescents themselves, the findings of this thesis highlighted the immense potential of eHealth prevention interventions for disadvantaged adolescents. However, they must be tailored to their unique needs, for maximum utility and effectiveness. In **Chapter 5** it was clear that the *Health4Life* intervention lacked sufficient context-specific messaging, which limited its acceptability among disadvantaged adolescents. Additional tailoring specific to low SES and/or regional adolescents would improve engagement and acceptability. **Chapter 2** further highlighted that a one-size-fits-all approach to preventing alcohol, tobacco, and vaping behaviours among disadvantaged adolescents, is inadequate – particularly due to variations in their prevalence across SES levels and geographical locations.

Chapter 6 demonstrated that adapting evidence-based programs – such as *OurFutures*, via co-designed adaptation with place-based end-users – to countries facing similar public health challenges, such as Colombia, may provide a sustainable and valuable model for health education and harm minimisation. This approach requires less financial investment than developing entirely new interventions and fast-tracks the roll-out of potentially engaging interventions (Movsisyan et al., 2021; Ospina-Pinillos et al., 2020).

Finally, policies aimed at improving digital literacy and access for disadvantaged adolescents are essential, so that they can fully benefit from eHealth interventions. Disadvantaged adolescents may engage with digital media differently than their more advantaged peers (Lim

et al., 2024): hence this may impact how well they benefit from digital health interventions. For instance, a study in Western Australia (Harris et al., 2017) reported that low SES adolescents had less access to computers in schools, and used their home computers for non-academic purpose – unlike high SES adolescents, who used their home computer for academic purposes. Considering this, incorporating support mechanisms such as visual aids and chatbots, could help improve disadvantaged adolescents' engagement and benefits from eHealth interventions (Maenhout et al., 2022).

7.3.2. Public Health

7.3.2.1. Prevention approaches to meet the needs of disadvantaged adolescents

Findings across this thesis highlight the importance of prevention approaches that address the unique needs of disadvantaged adolescents. As **Chapter 3** demonstrated, there is a paucity of effective eHealth interventions for disadvantaged adolescents – particularly for tobacco and vaping behaviours – and universal eHealth interventions at this point, might not be providing this cohort with sufficient benefits. Furthermore, as reported in **Chapter 2,** regional adolescents are faring considerably worse across alcohol and tobacco outcomes. More broadly, in **Chapter 4,** those participating in the *Health4Life* intervention demonstrated poorer dietary outcomes than the control students. Thus, prevention approaches are not adequately benefitting disadvantaged adolescents; thereby placing them at greater risk of chronic disease in the future, which is a significant public health concern. Intervention solutions in this scenario, include tailored campaigns to increase awareness of the risks of early exposure to these behaviours – especially early exposure to tobacco, for regional adolescents.

Taking this into account, prevention approaches should adopt holistic approaches – and consider the whole picture in relation to adolescents, including: (a) leveraging social networks, including parents and peers, to foster supportive environments conducive to healthy behaviour change; (b) incorporate appropriate supports to facilitate engagement with prevention, such as: including mental health components; and innovative tools, such as chatbots; (c) ensure that prevention interventions targeting diet, alcohol, tobacco, and vaping behaviours among disadvantaged adolescents, are underpinned by effective behaviour change theories; incorporate personalised feedback; and provide ongoing support (e.g. booster

sessions); as these were all important features identified in **Chapter 3**. The combination of recommendations from (a), (b), and (c), may facilitate behaviour change, both short-, and long-term, with greater benefits, relevance, and acceptability to disadvantaged adolescents. A key setting to deliver such prevention is in schools, where adolescents are already primed for learning. As such, eHealth-based interventions in this setting are ideal, as they provide an opportune moment to reach disadvantaged adolescents who may have limited resources, or who may not have access to such programs (as we saw in **Chapter 3** many are not available to them).

Prevention approaches should be developed using co-designed, place-based, end-user involvement, to ensure they are grounded in the lived experiences of the target population. This bottom-up approach improves relevance, and overcomes the issues of top-down approaches, that may overlook the nuances of specific groups. Indeed, the findings across thesis chapters support this approach, particularly for regional adolescents. For instance, despite *Health4Life* being co-designed with young people, they were predominantly a more affluent sample from major cities. Indeed, eHealth interventions that have not been co-designed with adolescents can impact their engagement and relevance (Psihogios et al., 2022). Additionally, co-designed approaches allow for the application of proportionate universalism, which advocates for interventions proportionate to the level of need – without the excluding or stigmatising effect, that may occur in selective or indicated approaches (Carey et al., 2015). An example of this in practice, may be all adolescents receiving a school-based eHealth intervention targeting poor diet, alcohol use, tobacco smoking, and vaping – with quizzes, videos, and activities, embedded within the platform. For low SES and regional adolescents, additional resources tailored to their context (e.g. tips for affordable healthy eating, offline-accessible content) could be included. The appropriate delivery of proportionate universalism measures, should also be tested with end-users.

7.3.2.2. Intervening early and targeting lifestyle risk behaviours collectively, particularly for those at risk

The timing of delivering prevention efforts is crucial for halting health inequities from widening. While Champion et al. (2021) found no significant sociodemographic differences in poor diet, alcohol use and tobacco smoking behaviours among adolescents aged 11-14, this age group is typically before the initiation age for alcohol and tobacco use in Australia (Gardner, Stockings, et al., 2024; Guerin & White, 2018). In contrast, in **Chapter 2**, which

analysed an older sample (14-17 years), disparities in these behaviours by SES and geographical location became apparent. Thus, to address these widening gaps, prevention approaches must intervene early and adopt targeted approaches. The modifiable nature of these behaviours offers hope for positive behaviour change before they become entrenched and track into adulthood.

As demonstrated in **Chapter 2**, poor diet, alcohol, tobacco and vaping behaviours can cluster together, exacerbating existing disadvantages low SES and regional adolescents already experience. Therefore, prevention efforts should target these risk behaviours collectively, including via MHBC interventions. Moreover, **Chapter 4** further highlighted the importance of considering the role of SES and geographical location on intervention efficacy. Thus, prevention approaches should adopt a holistic approach that target the interconnected nature of these lifestyle risk behaviours while also addressing social determinants of health.

7.3.3. The *Health4Life Initiative* and *OurFutures* programs; next steps

Addressing the unique needs of disadvantaged adolescents is essential to ensuring that programs such as *Health4Life* and *OurFutures* are accessible, relevant and effective in promoting behaviour change. This section outlines the directions for refinements to achieve this, including the prioritisation of co-design, user experience improvements and cultural adaptations.

7.3.3.1. Directions for further refinements and research – Health4Life for disadvantaged adolescents in Australia

The findings of **Chapters 4** and **5** indicate that without co-designing an adapted version of *Health4Life* with disadvantaged adolescents, the engagement with and utility of the program may be compromised. As such, the initial step of future research should focus on improving the user experience issues identified in **Chapter 5**. These include integrating activity worksheets into the *Health4Life* platform, minimising repetitive worksheets, reducing on-screen text to fit within speech bubbles, resolving website glitches, and improving teacher account administrative privileges to simplify resetting passwords.

Once these refinements are made, focus groups and co-design workshops with a representative sample of disadvantaged adolescents and their teachers are needed to: (1) test

and provide feedback on the improvements made in the first step to the user experience; and (2) address additional barriers to acceptability identified in **Chapter 5**. Regarding, point (2), this includes addressing: (a) the content quality, by making language and storylines more relatable and interesting; (b) structural concerns, by determining the best length of the program and redistributing content across modules for a balanced workload; (c) design issues, by creating more appealing graphic designs; (d) accessibility concerns, by determining suitable voiceover options, and organising material that could be offered offline; and (e) digital literacy difficulties, by determining necessary supports such as how step-by-step instructions on how to log in and use the website—both written and via a recorded video—should appear, and explore the potential benefits of integrating a chatbot for instant assistance.

Given parents and peers can influence adolescent behaviours and support improved lifestyle risk behaviour outcomes (Champion et al., 2022; Osman et al., 2024; Veenstra & Laninga-Wijnen, 2022), involving them in these focus groups and co-design workshops may further improve *Health4Life*'s relevance and impact for disadvantaged adolescents. While the *Health4Life* research team are currently evaluating a parent-focused component to complement *Health4Life* for disadvantaged adolescents, further exploration of a peer-led component is recommended.

7.3.3.2. Directions for further refinements and research – OurFutures Alcohol Module in Colombia

Chapter 6 provided key insights for adapting the *OurFutures Alcohol Module* to the Bogotá context. As this is only one Colombian context, future research should build on this work, to guide the adaptation of the program to multiple/all Colombian contexts. Thus, affording the cultural and contextual relevance for Colombian adolescents nationwide.

This adaptation process should begin with co-design workshops with adolescents and teachers, across multiple diverse regions of Colombia. These workshops should involve collaboratively addressing the areas identified in **Chapter 6** for improvement including: (a) contextualising/localising language; (b) representing alcohol beverages in a culturally appropriate way; (c) incorporating relatable and diverse characters; (d) updating storylines; (e) brainstorming ideas to make the educational content suitable for different ages; and (f) adjusting the program format. These workshops may involve creating region-specific

variations of the adapted program to ensure its relevance across Colombia, similar to the approach used in the Australian *Strong & Deadly* intervention based on the *OurFutures prevention model* (Snijder et al., 2021; Stapinski et al., 2022). *Strong & Deadly* is a culturally inclusive alcohol and other drug prevention program.

Following these refinements, the adapted six-lesson program(s) must be evaluated via a pilot study or RCT. This trial should simultaneously assess the relevance of the behaviour change principles underpinning the program, while considering the contextual factors influencing behaviour change outcomes in educational settings. Additionally, process evaluation data should be collected to support ongoing program improvements.

This iterative process will ideally facilitate the development and dissemination of a relevant, acceptable, and effective standardised alcohol prevention program for Colombia, that has the potential to make a real-world impact in terms of improving the chronic disease risk profiles of Colombian adolescents. Conducting sub-group analyses of low SES and regional adolescents in the trial will be important for determining if additional supports are needed, applying the principles of proportionate universalism where necessary.

7.3.4. Future directions for researchers

The following section provides recommendations for researchers based on the findings of this thesis.

7.3.4.1. Prioritising disadvantaged adolescents in research

Future research must prioritise the inclusion of disadvantaged adolescents, as they are often underrepresented in studies. Recruitment of these disadvantaged adolescents can be challenging, for instance: gaining ethics approval from Australian government schools' ethics boards often requires greater time and resources and may not always be feasible within short study periods or funding timelines, yet is crucial for gaining access to recruit large cohorts of disadvantaged school students (Australian Bureau of Statistics, 2022d; Productivity Commission, 2024).

Considering the findings of **Chapter 4**, research must consider sociodemographic influences (SES and geographical location) in intervention design, and replicate and explore potential explanations for the conflicting diet-related outcomes reported by geographical location in

Chapter 4. This will be key for informing improvements in future interventions targeting dietary behaviours among disadvantaged adolescents. Additionally, the evolving landscape of vaping among young people presents an urgent research priority, but particularly among disadvantaged adolescents given the lack of eHealth interventions targeting vaping identified in the **Chapter 3** systematic review. It is thus essential to develop and rigorously evaluate interventions specifically targeting vaping among low SES and regional adolescents. Such studies must ensure the publication of all findings, including null or iatrogenic results, to contribute to the evidence base and support the development of effective strategies tailored to disadvantaged adolescents. Moreover, regularly updated systematic reviews of eHealth interventions targeting poor diet, alcohol use, tobacco smoking, and vaping among disadvantaged adolescents are crucial as: (a) only diet and alcohol-related interventions had significant intervention effects, thus it is yet to be seen whether tobacco and vaping eHealth interventions are effective for disadvantaged adolescents; (b) to track whether disadvantaged adolescents are a target for eHealth interventions or continue to be neglected from focus in eHealth prevention research; and (c) to inform future eHealth prevention interventions on effective approaches to targeting each lifestyle risk behaviour and subsequently help improve chronic disease risk profiles of disadvantaged adolescents.

7.3.4.2. Improving intervention design and evaluation for disadvantaged adolescents

Although no effective eHealth interventions targeting tobacco use among disadvantaged adolescents were reported in the **Chapter 3** systematic review, previous research has suggested interventions underpinned by Social Cognitive Theory have the potential to reduce tobacco smoking among adolescents (Champion et al., 2013; Skov-Ettrup et al., 2014). Future research should evaluate this, alongside testing whether the same theoretical frameworks guiding tobacco interventions are suitable for leading to behaviour changes in vaping interventions. Moreover, as highlighted by **Chapter 3**, there is a need for future research on school-based eHealth interventions among disadvantaged adolescents to embed detailed process evaluations with student and teacher data into study evaluations; **Chapter 5** highlighted the benefits of gaining this process evaluation data to help elucidate the findings of **Chapter 4** unexpected effect among regional adolescents on poor diet outcomes. Ultimately, process evaluations can support informing future iterations and improvements to the intervention to maximise its relevance for disadvantaged adolescents.

Intervention-supporting components such as chatbots, voiceovers, and peer or parent involvement (as suggested in **Chapter 5**) in eHealth school-based interventions for disadvantaged adolescents should be systematically evaluated to determine their contribution towards improving program engagement and outcomes. These components could be tested using a stepped wedge RCT to determine their incremental benefits. Interventions must also be piloted and tested in diverse contexts prior to publicly disseminating, including outside of their original development setting, to determine their feasibility and efficacy.

7.3.4.3. Framework for place-based end-user co-design

To facilitate an efficient process for future researchers to develop eHealth interventions for disadvantaged adolescents, establishing a framework for conducting place-based, end-user co-design of such interventions is needed. Ospina-Pinillos et al. (2020) have described a framework for developing a language-appropriate, culturally sensitive, and contextually adapted intervention, which could be further refined to incorporate greater pathways for creating scalable and widely available co-designed interventions. For instance, such frameworks could include procedures for researchers to share insights and updates from their experiences, to allow for greater application of effective, or useful, co-design principles in certain settings.

7.3.4.4. Collecting and analysing longitudinal data

In Australia, as disadvantaged adolescents are considerably underrepresented in national datasets and longitudinal studies, the ability to analyse trends and causality of lifestyle risk behaviours by sociodemographic factors is limited. Therefore, greater investment in longitudinal research is needed to disentangle the influence of SES and geographical factors on lifestyle risk behaviours, alongside the long-term effects of eHealth interventions in delaying or preventing lifestyle risk behaviours. Ongoing monitoring and analysis of these behaviours are essential for developing and refining effective prevention strategies.

7.4. Conclusions

This thesis offers a significant and novel contribution to adolescent health and chronic disease prevention by investigating how SES, geographical location, and lifestyle risk

behaviours such as poor diet, alcohol use, tobacco smoking, and vaping intersect. The first key insight of this thesis is that regional adolescents reported a significantly higher prevalence of alcohol and tobacco smoking behaviours compared to their peers in major cities. This finding raises public health concerns due to the potential of these disparities to exacerbate existing disadvantages to health regional adolescents experience. Secondly, while eHealth interventions showed promise in improving dietary habits and reducing alcohol consumption among disadvantaged adolescents, there is a lack of evidence for their effectiveness in reducing tobacco use and vaping. Thirdly, there was little evidence for a moderation effect of SES and geographical location on the efficacy of the universal school-based *Health4Life* intervention on most outcomes. The exception to this was for diet-related outcomes by geographical location: regional adolescents in the intervention group reported poorer diet compared to the control group; whereas adolescents in major cities in the intervention group reported greater intentions to swap SSBs for water compared to the control group. Fourthly, the process evaluation of *Health4Life* among disadvantaged adolescents demonstrated that they rated the intervention less favourably than the entire sample, with content and technical issues impacting their experience. Nonetheless, the identification of facilitators and barriers to their participation in the intervention were collected and will be crucial for informing the co-designed adaptation of the intervention for them. Finally, this thesis provided evidence for the acceptability of effective evidence-based digital interventions developed in Australia, such as the *OurFutures Alcohol Module*, in other less advantaged contexts, specifically, Bogotá, Colombia. In this study both adolescents and teachers reported high satisfaction with the *OurFutures Alcohol Module* and provided recommendations for improvements. Together, these findings emphasise the necessity of addressing health inequities through co-designed, tailored, culturally sensitive, and scalable interventions. This thesis provides actionable recommendations for policy, public health, and research, offering a pathway to more effective and equitable lifestyle behaviour interventions. Enacting these recommendations has the potential to improve the chronic disease risk profile of disadvantaged adolescents worldwide.

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Appendix A

eHealth interventions targeting poor diet, alcohol use, tobacco smoking and vaping among disadvantaged adolescents: A systematic review

Appendix A

Preface

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LE conceptualised the study with assistance from all authors. LE conducted all article screening, data extraction, and wrote the original manuscript. LAG, NCN and KEC screened a subset of articles. LE and KEC conducted quality appraisal assessments of included studies. All authors were involved in reviewing the original manuscript, read and approved the final version and agreed to publication.

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A Systematic Review of eHealth Interventions Among Adolescents of Low Socioeconomic and Geographically Remote Backgrounds in Preventing Poor Diet, Alcohol Use, Tobacco Smoking and Vaping

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Abstract

Disadvantaged adolescents such as those of low socioeconomic and geographically remote backgrounds experience disproportionate chronic disease burden and tend to engage in greater risk behaviors including poor diet, alcohol use, tobacco smoking, and vaping. The social, structural, and economical barriers to health that uniquely affect adolescents of low socioeconomic and geographically remote backgrounds, such as stigma, access to and affordability of services, may partially explain their disadvantage in attaining health equity. Universal eHealth interventions can provide effective prevention, however, it is unclear whether they benefit disadvantaged adolescents, including those from low socioeconomic and geographically remote contexts. This study systematically reviewed the effectiveness of eHealth interventions targeting disadvantaged adolescents in preventing poor diet, alcohol use, tobacco smoking and vaping. Of 3278 identified records, 15 publications assessing 14 interventions were included, comprising 7170 youth (aged 9–18 years, 50.1% female, 56% low-mid SES, 33% remote). Nine interventions targeted poor diet, three targeted alcohol, one targeted tobacco, and one targeted alcohol and tobacco. No interventions targeted vaping. eHealth interventions significantly increased fruit and vegetable intake and percentage energy of nutrient-rich food, decreased sugar-sweetened beverage consumption, total energy intake, nutrient-poor food percentage energy consumption, and were associated with reduced binge drinking at 1-month follow-up among intervention completers. The findings of this study highlight that eHealth interventions can be effective in targeting poor diet and alcohol use among disadvantaged adolescents. However, due to the limited number of studies meeting inclusion criteria for this study, it is critical future research focus on developing and evaluating effective eHealth interventions targeting disadvantaged adolescents.

Keywords eHealth · Sociodemographic disadvantage · Diet · Alcohol · Smoking · e-cigarette

Introduction

Disadvantaged adolescent populations, including those from low socioeconomic and geographical remote contexts, experience exponentially greater chronic disease burden than their counterparts and report higher rates of engagement in modifiable risk behaviors such as poor diet, alcohol use, tobacco smoking and vaping (Australian Institute of Health & Welfare, 2019a). Chronic diseases detrimentally affect an individual's health and wellbeing, and are associated with significant social and economic costs; this effect is exacerbated with multimorbidity (Australian Institute of Health & Welfare, 2020b). There is an opportunity to alleviate disadvantaged adolescents' vulnerability to experiencing chronic disease burden across their lifetime in a cost-effective way by focusing on the prevention of key lifestyle risk behaviors prior to their establishment in adulthood (Solar & Irwin, 2010). There is growing evidence to support the use of electronic health (eHealth) interventions in delaying or preventing the onset of modifiable lifestyle risk behaviors among the general population (Newton et al., 2022; Qiu et al., 2022), however, their effect on disadvantaged adolescents has not yet been synthesized. Therefore, the purpose of this study is to systematically synthesize the literature on eHealth interventions among disadvantaged adolescents in preventing poor diet, alcohol use, tobacco smoking and vaping.

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Disadvantage and Modifiable Lifestyle Risk Behaviors

Socioeconomic status refers to an individual's or group's social and economic position in relation to others in society (described as low, middle, and high), that affects access to resources and health outcomes (Australian Bureau of Statistics, 2011). In a country like Australia that covers 7 692 024 km^2, there are large geographic differences in where people live with long distances between major cities and rural and remote areas. As remoteness increases, accessibility to services and health outcomes decrease. For instance, according to 2018 figures populations living in remote and very remote areas experience 1.4 times greater burden of disease than those living in major cities (Australian Institute of Health & Welfare, 2022).

Although low socioeconomic status and geographic remote backgrounds represent unique contexts, they share similar disadvantages to achieving health equity. It is for this reason the term 'disadvantaged' is used to describe low socioeconomic and geographically remote in this study. Disadvantaged adolescent populations face a multitude of social, structural, and economical barriers to health, such as stigma (Robards et al., 2018), less social support (World Health Organization, 2016), access to and affordability of services, employment prospects and educational opportunities (Australian Institute of Health & Welfare, 2019c); and these may partly explain health inequity between population groups.

Importantly, lifestyle risk behaviors, such as poor diet, alcohol use, and tobacco smoking, are modifiable (GBD, 2019 Diseases & Injuries Collaborators, 2020). Preventing the uptake or reducing engagement in these behaviors can lessen global disease, illness, and morbidity. However, engagement with these behaviors differs across socioeconomic positions and between geographical areas; generally, more disadvantaged populations are faring worse. Australian children and adolescents living in the lowest socioeconomic area compared to the highest socioeconomic area report: lower fruit intake, higher consumption of sugar-sweetened beverages (SSBs), and an increased likelihood of risky alcohol consumption and smoking (Australian Institute of Health & Welfare, 2020a). Similar trends have been reported among disadvantaged adolescents overseas (Palakshappa et al., 2020; Shackleton et al., 2019). Vaping (electronic cigarette or "e-cigarette" use), however, emerged relatively recently, and is becoming increasingly more common among adolescents across the world (Tarasenko et al., 2021), despite growing evidence of the harmful health effects (Banks et al., 2022). The UK Household Longitudinal Study reported greater e-cigarette use among socioeconomically disadvantaged youth, particularly among never-smokers (Green et al., 2020), and the 2018–2019 Kansas Communities That Care Student Survey reported a higher prevalence of current e-cigarette use among adolescents from rural areas compared to urban areas (Dai et al., 2021).

Adolescence as a Key Stage for Prevention

Prevention interventions targeted at adolescents provide a unique opportunity to prevent key lifestyle risk behaviors as they are ideally delivered prior to the onset and entrenchment of such behaviors. This is on account of adolescence marking a critical period of growth and development where patterns for current and future life behaviors start to take form, often accompanied by increased risk-taking behavior that can positively (e.g. competitive team sport) or negatively (e.g. substance use) influence health (Duell & Steinberg, 2019). The initiation of vaping, alcohol and tobacco use typically increases during adolescence (Degenhardt et al., 2016; Hammond et al., 2019), and dietary habits characteristically include greater consumption of nutrient-poor food (Murakami & Livingstone, 2016) including junk food (Australian Institute of Health & Welfare, 2018) and SSBs (Australian Institute of Health & Welfare, 2019b). These behaviors commonly cluster together (Gardner et al., 2022) and have been regarded as "consumption behaviors" (Thornton, 2022), suggesting that consuming food, alcohol, or tobacco requires active participation. Short-term consequences associated with these behaviors include obesity (Bleich & Vercammen, 2018), diminished quality of life (Hoare et al., 2019a, 2019b), and behavioral and mental health problems (Hoare et al., 2019a, 2019b). Many of these behaviors may persist into adulthood (Degenhardt et al., 2008), increasing chronic disease risk, particularly when they co-occur (Ding et al., 2015). Preventing these behaviors in adolescence is critical for safeguarding future health outcomes of disadvantaged populations, and engaging in health-promoting behaviors in adolescence shows promise in improving adolescent and adult health outcomes (Liu et al., 2012).

Viability of eHealth Interventions and Existing Systematic Reviews

Pertinent to the design of prevention interventions is consideration of the unique barriers experienced by disadvantaged adolescent populations. Electronic health (eHealth) interventions (e.g., computer-, web-, mobile-, or telephone-based) may be a viable option as they can be accessed remotely, at little cost to the end-user, and provide increased implementation fidelity and student engagement (Newton et al., 2017). As adolescents are high users of technology (Patton et al., 2016), eHealth provides an opportunity to connect with disadvantaged adolescents who may otherwise miss out on receiving interventions due to the aforementioned barriers.

Several systematic reviews of eHealth interventions targeting poor diet, alcohol use, and/or tobacco smoking among adolescents have reported their effectiveness in: improving dietary behaviors (e.g. less unhealthy food and total fat and saturated fat consumption, and increased daily fruit and vegetable intake) (Kemp et al., 2021); reducing alcohol use (Hutton et al., 2020; Kazemi et al., 2021); and reducing the number of cigarettes and smoking frequency (Taylor et al., 2017). These reviews, however, focused on adolescents in the general population, and reviews on vaping are lacking. To date, no existing systematic review has focused specifically on eHealth interventions among adolescents living in geographically remote areas and/or of lower socioeconomic contexts targeting poor diet, alcohol use, tobacco smoking and vaping.

The Current Study

Due to the disproportionate chronic disease burden experienced by disadvantaged adolescents, innovative, effective and accessible prevention approaches are needed. Universal eHealth interventions among adolescents can provide effective prevention, therefore may be a practical option for preventing lifestyle risk behaviors such as poor diet, alcohol use, tobacco smoking and vaping among disadvantaged adolescents. However, the research on the effect of eHealth interventions among disadvantaged adolescents has yet to be systematically synthesized. This study aimed to address gaps in the literature by systematically reviewing the evidence on the effectiveness of eHealth interventions targeting adolescents (aged 10–19 years) from disadvantaged backgrounds in preventing poor diet, alcohol use, tobacco smoking, and vaping. It was hypothesized that eHealth interventions targeting these risk behaviors among disadvantaged adolescents would be limited in number and effect, especially those targeting vaping due to its relatively recent emergence among adolescents and the paucity of research focused on vaping.

Methods

This systematic review was prospectively registered with PROPSERO (CRD42021294119) and was written as outlined in the published review protocol (Egan et al., 2022) and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols guidelines (Moher et al., 2015).

Search Strategy and Selection Criteria

A systematic search of seven electronic databases (Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, PROSPERO, MEDLINE [Ovid], Embase [Ovid], Scopus, and PsycInfo [Ovid]) was conducted December 19, 2022. An example search for MEDLINE [Ovid] is provided in the appendix (p 20). The search strategy was developed in consultation with a research librarian, and search terms were guided by the population, interventions, comparators, and outcomes (PICO) approach (Shamseer et al., 2015). Eligible studies were those that evaluated an eHealth intervention targeting poor diet, alcohol use, tobacco smoking, or vaping among adolescents aged 10–19 years (in line with the World Health Organization's definition for "adolescents" (World Health Organization, 2021)) of low socioeconomic or from geographically remote backgrounds. The comparator groups included participants in a control group (e.g. no intervention) or assessed outcomes based on changes over time. Randomized controlled trials and quasi-experimental studies, with no language or publish date restrictions were included. Studies were excluded if there was no clear eHealth intervention component or if interventions were targeted at the general population without specific sub-group analysis among disadvantaged adolescents.

Data Extraction

All identified articles were imported into EndNote software (Clarivate) for removal of duplicates, and subsequently uploaded to Covidence software (Covidence) for screening. The reference lists of eligible studies were also searched to identify additional studies. Study titles and abstracts were independently reviewed by one author, and a subset (25%) of articles were double screened by the remaining study authors. Any disagreements were resolved through consultation. Data were extracted by one author using a standardized extraction form guided by the Template for Intervention Description and Replication checklist (Hoffmann et al., 2014), and reviewed by a second author.

Data Analysis

The primary outcome of interest was the prevention or reduction of alcohol (any consumption, total weekly-monthly alcohol consumption, heavy drinking, and frequency of binge drinking), tobacco (current vs non-smoker), and e-cigarette use, and improvements in dietary behaviors, including intake of fruit and vegetable, SSBs and nutrient-poor foods (junk food). Secondary outcomes included knowledge, intentions, and other health behaviors including physical activity, sleep and recreational screen time. Two authors independently assessed the risk of bias of included studies using the Cochrane Revised Risk of Bias Tool (Sterne et al., 2019). Any discrepancies between assessors

were resolved through consultation. Study findings were summarized qualitatively following the UK Economic and Social Research Council guidance for narrative synthesis in systematic reviews (Popay et al., 2006).

Results

An overview of the study selection process is shown in a PRISMA flow diagram (Fig. 1). A total of 3601 articles were identified, with 15 articles (covering 14 trials) included for extraction. There was substantial inter-relater reliability present at full-text screening (Cohen's *K* 0.625; 81% agreement). A summary of study characteristics is shown in Table 1.

Study Characteristics

Across the 14 trials, 7170 youth aged between 9 and 18 years took part, with an average of 50.1% female (for studies reporting sex), and 56% low-mid SES, and 33% remote. Trials predominantly included both males and females, with the exception of two trials that evaluated solely a male population (Lubans et al., 2016; Smith et al., 2014) and female population (Nollen et al., 2014). Studies were predominantly conducted in the USA ($n=8$; 57%), and study designs included cluster randomized controlled trials ($n=6$; 43%), randomized controlled trials ($n=4$; 29%) and quasi-experimental studies ($n=4$; 29%). Sample sizes ranged from 46 to 3213 adolescents, with intervention length varying between 20 min to 25-months and follow up periods ranging from one month to 25-months. Comparators were most commonly education as usual ($n=4$; 29%) or waitlist control ($n=4$; 29%), however, two studies (14%) did not have a control group, and instead examined between group comparisons.

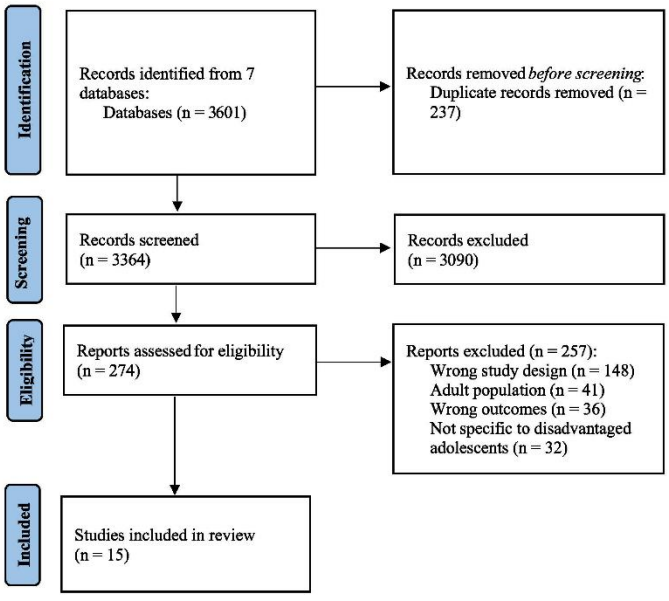

Fig. 1 Identification of studies via databases

Nine trials (Cremers et al., 2015; Frenn et al., 2003, 2005; Lubans et al., 2016; Martinez-Montilla et al., 2020; Nollen et al., 2014; Smith et al., 2014; Tripicchio et al., 2017; Voogt et al., 2013; Wright et al., 2013) were conducted among adolescents of low socioeconomic status, four (Chai et al., 2021; Davis et al., 2016; Gustafson et al., 2019; Hongthong & Areesantichai, 2016) were among adolescents living in geographically remote areas, and one focused on adolescents of both low socioeconomic and geographically remote backgrounds (Murry et al., 2019).

Nine trials (Chai et al., 2021; Davis et al., 2016; Frenn et al., 2003, 2005; Gustafson et al., 2019; Lubans et al., 2016; Nollen et al., 2014; Smith et al., 2014; Tripicchio et al., 2017; Wright et al., 2013) targeted diet, three (Hongthong & Areesantichai, 2016; Martinez-Montilla et al., 2020; Voogt et al., 2013) targeted alcohol, one (Cremers et al., 2015) targeted tobacco, and one (Murry et al., 2019) targeted both alcohol and tobacco. No studies targeted vaping.

Intervention Characteristics

Most interventions were either standalone eHealth ($n=11$ Chai et al., 2021; Cremers et al., 2015; Davis et al., 2016; Frenn et al., 2005; Gustafson et al., 2019; Hongthong & Areesantichai, 2016; Martinez-Montilla et al., 2020; Murry et al., 2019; Nollen et al., 2014; Voogt et al., 2013; Wright et al., 2013)) or mainly eHealth ($n=1$ (Frenn et al., 2003)) interventions, and primarily used computer-based methods (e.g., websites) to deliver the intervention, followed by telephone (including SMS), and telemedicine (e.g., Skype).

Twelve studies cited theoretical underpinnings for their interventions, most commonly Social Cognitive Theory ($n=3$; 21%) and the I-Change Model ($n=3$; 21%). Eight studies (Chai et al., 2021; Cremers et al., 2015; Davis et al., 2016; Gustafson et al., 2019; Hongthong & Areesantichai, 2016; Martinez-Montilla et al., 2020; Murry et al., 2019; Nollen et al., 2014) (57%) evaluated an intervention that was co-designed with end users and key stakeholders (including at least one of the following groups: adolescents; teachers; parents; community members; health care professionals).

Primary Outcomes

Primary outcome data relating to poor diet, alcohol use and tobacco smoking for each trial is shown in Table 1.

Dietary Intake

Of the eight trials assessing dietary outcomes, compared to a control group three eHealth interventions were significantly associated with: increased fruit and vegetable intake

Table 1 Characteristics of included studies

	Study design and key sample demographics	Targeted risk behaviours	Primary outcomes	Secondary outcomes	Interventions/mode of delivery	Measurement tools	Intervention components	Who provided	Intervention frequency and duration
Chai et al. (2021)	Three-arm pilot RCT; Australia; 1 urban and 2 rural locations; n = 46 families; Children—9 years (SD 2.3), 41% female, BMI ≥ 21.5 kg/m^2; 61% urban families, 39% rural families; 15% low SES, 65% mid SES, 20% high SES	Diet, physical activity	Total dietary energy intake (kJ) and percentage energy (%E) from nutrient-rich foods (e.g. fruit and vegetables) and energy-dense, nutrient-poor foods (e.g. fried food)	Child physical activity level (PAL); Child BMI; zBMI; waist circumference	*Back2Basics* family-based intervention INT1: Telehealth- website-based with healthy cooking videos; telehealth consultations; Facebook group; INT2: Telehealth + SMS = INT1 + text messages	Objective height and weight; parent-reported FFQ (child version of Australia Eating Survey, Physical Activity Questionnaire for Children)	INT1: website education on nutrition; telehealth consultations with a dietician guided by CALO-RE taxonomy of behaviour change techniques on healthy eating behaviours; personalised dietary report and family food goals; Facebook group for parents and researchers to engage and post relevant research topics, respectively; INT2: INT1 but separate Facebook group and 42 text messages on healthy eating sent to parents	Accredited practicing dietitians used the CALO-RE taxonomy of behaviour-change techniques pertaining to healthy eating for semi-structured telehealth consultation with families via videoconferencing software "Scopia". The SMS messages were informed by evidence-based literature, and refined by parents and health experts	INT1: 12-week access to Back2Basics website (new topics released each week) + Two 20-min telehealth consultations; INT2: INT1 and 42 SMS delivered over 12-week study period to parents
Cremers et al. (2015)	Three-arm cluster RCT; The Netherlands; 162 schools; n = 3213; 10.36 (SD 0.55); 50.86% female; 88.27% Western; 57.86% low SES	Tobacco smoking	Smoking behaviour (current smoker vs non-smoker)	Intention to start smoking; attitude; social influence; self-efficacy	INT1: Email and SMS prompts to use *Fun Without Smokes* website; INT2: No prompts	Online self-report survey	Wed-based, computer-tailored; online questionnaire covering participants' smoking behaviour, intention to smoke, and smoking-related sociocognitive factors (including attitude, social influence, and self-efficacy); feedback messages based on participants' responses to questionnaire via email and int website; INT1 (prompt group) received 12 prompts via email and SMS to revisit *Fun Without Smokes* website; INT2 (no prompt group) received computer-tailored feedback messages on three consecutive days with advice on smoking attitudes, perceived social influence and self-efficacy expectations to refuse cigarettes	Online	Three self-report questionnaires (baseline, 12 and 25 months after baseline); nine tailored feedback messages (three after each questionnaire) for INT1 and INT2 groups; 12 prompt emails and SMS (six per year) for INT1 group; over 25-months

Table 1 (continued)

	Study design and key sample demographics	Targeted risk behaviours	Primary outcomes	Secondary outcomes	Interventions/mode of delivery	Measurement tools	Intervention components	Who provided	Intervention frequency and duration
Davis et al. (2016)	Two-arm cluster RCT; USA; 11 schools in rural areas (city and/or county population < 20,000); n = 103 overweight (57.28%; 85th ≤ BMI percentile ≤ 95th) or obese children (47.72%; BMI percentile ≥ 95th) and their caregivers; 9.14 years (SD 1.86); 55.34% female; 88.24% Caucasian; 40.2% eligible for free or reduced lunch	Diet, physical activity	Daily intake of calories, percent calories from fat, fruit and vegetable servings, sugar-sweetened beverage servings, and servings of "red" foods (i.e. more than 12 g of sugar and/or 7 g of fat)	Child and parent BMI; objective MVPA/day; child competencies and behavioural or emotional problems; mealtime behaviour problems; obesity related quality of life	INT1: Family-based telephone meetings at school in groups; INT2: Family-based telemedicine meetings at school in groups	Objective height and weight; telephone survey with parents (child's 24-h dietary recall, accelerometers (ActiGraph); Child Behaviour Checklist (CBCL), Behavioural Pediatrics Feeding Assessment Scale (BPFAS)); child self-report of obesity related quality of life and parent-proxy report	INT1: Parent and children groups separately had telephone meetings with research team covering manualised topics focused on behaviour, nutrition and physical activity; INT2: Same as INT1 however sat around TV screen for audio and video communication instead of telephone	On-site representatives at each school (often a nurse, PDHPE or computer teacher) were trained on procedures for recruitment, consent, intervention-related activities, and taking anthropometric measurements. An intervention manual was also provided to them Off-site leaders (a research team clinician)	14 one-hour group meetings (initially eight weekly followed by six monthly) for parent and child groups separately, over 8-months
Frenn et al. (2003)	Quasi-experimental design; USA; two urban low-middle income schools; n = 341; 12–15 years (M & SD NR); 56.9% female; 51·5% African American; 41 students eligible for free lunch and 15 reduced fee[a]	Diet, physical activity	Percentage dietary fat	Moderate-to-vigorous physical activity (past 7 days)	INT: Internet-based lessons; videos; healthy snack session; gym class	Online self-report surveys to classify participants to their respective stage of change in the Transtheoretical Model; Access to low-fat foods and exercise areas and programs was included in survey post-test; The Food Habits Questionnaire and the Child and Adolescent Activity Log (CAAL)	Internet-based lessons with short videos of actors acting out content; online feedback based on participants' Transtheoretical Model stage of change; online food diary with feedback; peer-led healthy snack session; peer-led physical activity gym class (one school only)	Internet and video intervention components – Online; Healthy food and exercise labs—peers under supervision from "senior nursing students and faculty"	Four 50-min internet lessons; one 50-min healthy snack session (session 4) over one school year, with one school also receiving one 50-min gym classes

Table 1 (continued)

	Study design and key sample demographics	Targeted risk behaviours	Primary outcomes	Secondary outcomes	Interventions/mode of delivery	Measurement tools	Intervention components	Who provided	Intervention frequency and duration
Frenn et al. (2005)	Quasi-experimental design; USA; one urban public middle school; n = 103 low-income, culturally diverse, seventh-grade students; 12–14 years (M & SD NR); sex NR; ethnicity NR	Diet, physical activity	Percentage dietary fat	Moderate-to-vigorous physical activity (past 7 days)	INT: internet-based lessons, videos, online discussion board, email	Online self-report survey (Staging questions for dietary behaviour and physical activity, Food Habits Questionnaire and Child and Adolescent Activity log)	Blackboard—online portal / learning management system—with four 2–3 min videos; computer-generated tailored feedback provided based on participants' Transtheoretical Model stage of change; online discussion board; personalised email feedback	Online	Eight 40-min lessons over 1 month
Gustafson et al. (2019)	Two-arm cluster RCT; USA; 8 rural high schools; n = 411; 14–16 years (M = 15yrs; SD NR); 64% female; 63.5% White	Diet	Fruit and vegetable servings/day; Daily SSB intake	Body Mass Index (BMI) Z-score; home food availability; purchasing habits; self-efficacy; goal setting related to healthy eating	INT: Mentor-led text messages via Group Me app or email	National Cancer Institute Fruit and Vegetable Screener, BEV-Q10 questionnaire, self-reported height and weight	Go Big and Bring it Home (GBBH) Facebook page; Group Me mobile application or e-mail if participant did not have a mobile; affective text messages including a weekly challenge related to consuming fruits, vegetables, or healthy/low-calorie beverages; tailored messages dependent on participants' response to initial message; $5 each week if participant responded to messages sent on Tuesday and Saturday; gift cards to Mentor for participating	Mentors: 34 undergraduate human nutrition and dietetics students. They were given 1-h training on sending text messages through the Group Me app on Tuesday and Saturday every week over the study period and supervised by 4 Master of Science/Registered Dietician graduate students at the University of Kentucky	Two text messages per week over 8 weeks

Table 1 (continued)

	Study design and key sample demographics	Targeted risk behaviours	Primary outcomes	Secondary outcomes	Interventions/mode of delivery	Measurement tools	Intervention components	Who provided	Intervention frequency and duration
Hongthong and Areesantichai (2016)	Quasi-experimental design; Thailand; two high schools in rural Thailand; n = 150 low-risk drinkers; Intervention 16.57 years (SD 0.57), 64% female, US$290.64 (SD 30.15) family income per month, ethnicity NR; Control 16.45 years (SD 0.50); 58.67% female, US$306.34 (SD 41.16) family income per month, ethnicity NR	Alcohol	NA	Alcohol knowledge	INT: *PALMSS*[b] alcohol prevention program – CD-ROM based modules	Self-report questionnaire (modified School Health and Alcohol Harm Reduction Project (SHAHRP))	CD-ROM based modules with increasing complexity each week (1. Alcohol knowledge, 2. Low-risk drinking, 3. Social drinking, 4. Media influence, 5. Resisting peer pressure, 6. Self-efficacy); questionnaire (the Alcohol Knowledge Test)	CD-ROM	Four 50-min modules, one delivered per week via CD-ROM over 1 month
Lubans et al. (2016); Smith et al. (2014)	Two-arm cluster RCT; Australia; 14 schools in low-income communities; n = 361 at risk of obesity; 12.7 years (SD 0.5); 100% male; Cultural background—77% Australian, 15% European; 29% in the lowest SES band	Diet, physical activity, screen-time	SSB intake, glasses/d	Percent moderate-to-vigorous physical activity; screen-time, min/d; BMI z-score; BMI (kg.m − 2); waist circumference (cm); accelerometer counts/min; grip strength, kg; push-ups (repetitions); resistance training skill competency; Intrinsic regulation; Identified regulation; Introjected regulation; External regulation; Amotivation	INT: *ATLAS*[c] school-based program; supplementary website and smartphone application; parent newsletters	Objective height, weight, and accelerometer counts/min; self-report survey (modified Adolescent Sedentary Activity Questionnaire, NSW Schools Physical Activity and Nutrition Survey, adapted version of Goudas et al. scale); handgrip dynamometer; 90° push-up test; Resistance Training Skills Battery	INT: School-based; teacher professional learning workshops; personal trainer delivered session; necessary fitness equipment provided; physical activity sessions; researcher delivered seminars to participants; student-led physical activity session during lunchtime; website and smartphone application to report daily step counts from pedometers, review fitness challenge results, conduct peer assessment of resistance training skill competency, set goals for screen-time and physical activity; tailored motivational messages via the app based on participant responses; pedometers to self-monitor physical activity; parent newsletters with information on reducing screen-time sent via mail	Teachers that had completed 2 × 6 h professional development workshops delivered the *ATLAS* physical activity sessions to participants	Over 20-weeks (across two school terms): two 6-h teacher professional development workshops and 1 personal trainer session; four newsletters to parents (two each term); three 20-min researcher-led seminars; twenty 90-min ATLAS school sport sessions; six 20-min student-led physical activity sessions during lunchtime; 15-weeks access to ATLAS app/website; 17-weeks use of pedometers

Table 1 (continued)

	Study design and key sample demographics	Targeted risk behaviours	Primary outcomes	Secondary outcomes	Interventions/mode of delivery	Measurement tools	Intervention components	Who provided	Intervention frequency and duration
Martinez-Montilla et al. (2020)	Two-arm cluster RCT; Spain; 15 public high schools; n = 1247; 16.32 years (SD 1.07); 53% female; 94.69% Spanish; 2.76% low family affluence, 32.30% medium family affluence, 64.94% high family affluence	Alcohol	Alcohol consumption (binge drinking, heavy episodic drinking, weekly consumption, any consumption)	NA	INT: *Alerta Alcohol* school-based computer-tailored lessons	Online self-report questionnaire	INT: Internet-based cartoon lessons; tailored messaging to reduce alcohol consumption and binge drinking and enhance self-esteem and awareness of risks associated with alcohol consumption and binge drinking; challenge to not drink/binge drink for upcoming event, advice and action plans; key concepts included attitude, social influences, self-efficacy and action planning	A researcher supervised all groups completing the baseline and follow-up questionnaires and a school teacher assisted participants in intervention group when required	Six 1-h sessions (four at school and two booster sessions at student home 1-week after third session)
Murry et al. (2019)	3-arm RCT; USA; n = 421 youth & caregivers in five rural Tennessee counties (rurality index score > 11 [16 or greater = most rural], 30% of residents were African American, poor health outcomes based on state health indicators e.g. health behaviours); 11–13 years (SD NR); 54% female; ethnicity NR; 14% of caregivers received public assistance	Alcohol and tobacco use	NA	Substance use (alcohol, tobacco, cannabis, cocaine, hallucinogens, methamphetamines, heroin, MDMA, or prescription drug use)[d]; Intention to engage in risk behaviours; affiliation with deviant peers; Youth vaginal, anal, and oral sexual behaviours; parenting behaviours (supportive parent–youth relationship, adaptive racial socialisation, communication about sex, clear communication of rules and expectations about substance use)	Promoting African American Success (PAAS) program delivered in community settings; INT1: technology (computer-based); INT2: small in-person group	Youth self-report survey (Sexual Risk Survey, Monitoring the Future scale); parent self-report survey (Carver Caregiver Support scale, Discussion Quality Scale, Racial Socialization scale, Frequency of Sexual Communication scale, Substance Use Rules Communication Scale from Strengthening Families)	INT1: Computer-based lessons (parent and youth on separate computers); off ramps and side streets demonstrate outcomes of choices and consequences; characters physically and vocally resembling members of the local community; participants choose avatars to represent themselves; family sessions (parent and youth together) discussion questions and optional viewing of video portrayal and modelling for each discussion topic; $25 for family attendance INT2: small in-person groups; concurrent parent and youth sessions followed by family sessions; role play & skill practice, group discussions and time to ask questions; videotaping sessions for fidelity	INT1: two on-site trained (6 h of training on content and procedures) assistants INT2: trained program facilitators (36 h of training over 6 days—often African American community members)	INT1: 6 × weekly 1.5 h sessions; INT2: 6 × weekly 2 h sessions

Table 1 (continued)

	Study design and key sample demographics	Targeted risk behaviours	Primary outcomes	Secondary outcomes	Interventions/mode of delivery	Measurement tools	Intervention components	Who provided	Intervention frequency and duration
Nollen et al. (2014)	Two-arm randomised pilot trial; USA; n = 51 low-income minority girls; 11.3 years (SD 1.6); 100% female; 83% African American, 7.8% Hispanic/ Latina; 32.4% living in poverty, median annual household income US$27,388	Diet, screen-time	Fruit and vegetable consumption; sugar-sweetened beverage intake	Screen time	INT: Mobile-based modules; goal reminder and completion alarms; song	Self-report survey (24 h dietary recall*, Brief Questionnaire of Television Viewing and Computer Use) *Fruit and vegetable consumption was assessed at baseline and Week 4, and SSB was assessed at baseline and Week 8	INT: Handheld computer-based modules on fruits & vegetables, SSBs, screen time and goal setting; goal reminder and completion alarms; self-monitoring; song-based reward system (if responded to 80% of prompts)	MyPal A626 handheld computer	Over 12 weeks: two daily goals per module; reminder alarms up to three times over 6-min at pre-selected times with tips to reach goal; one song per day if participants responded to 80% of prompts they received
Tripicchio et al. (2017)	Quasi-experimental design; USA; urban paediatric clinics in Kansas City area; n = 64 overweight/ obese low-income youth (mean BMI percentile = 98.6); 9.6 years (SD 3.1); 32.8% female; 84.4% Hispanic	Diet, physical activity	NA	Fruit and vegetable consumption; servings of "red foods" (i.e., high in fat and calories, poor nutritional quality); Physical activity (mins/week); BMI-z scores	INT1: *Healthy Hawks* in-person family-based behavioural group (FBBG) program; INT2: INT1 + fitness app (FITNET); INT3: INT2 + personalised health-coaching sessions via Skype	Parent and child self-report servings of fruit and vegetables, "red foods", and physical activity via self-monitoring sheets; Anthropometric data collected via trained research staff; Youth physical activity measured automatically via FITNET app; Parent daily steps recorded via pedometers	INT1: 12 weekly 2-h in-person family-based behavioural group (FBBG) program for parents and children, separated for the first hour to cover educational sessions on strategies to promote behaviour change (i.e., goal setting, self-monitoring, parent role modelling, diet/ physical activity/lifestyle modification), followed by physical activity sessions; daily self-monitoring sheets for both parents and children to track servings of "red foods" (e.g. low in nutrients), fruit and vegetables, physical activity; incentive points for children if returned self-monitoring sheets each week; parents pedometers track daily steps; INT2: INT1 + fitness app (FITNET) on digital tablet for physical activity sessions at home with physical activity data automatically recorded via FITNET; INT3: INT2 + personalised health-coaching sessions via Skype on digital tablet, summary reports	INT1: Trained program staff INT2: Smartphone app INT3: Health coach trained on protocols, motivational interviewing and modification techniques	INT1: 12 weekly 2-h in-person FBBG; INT2: INT1 + 30–60 min PA per week up to per day over study period; INT3: INT2 + 5 × 30-min skype sessions

Table 1 (continued)

	Study design and key sample demographics	Targeted risk behaviours	Primary outcomes	Secondary outcomes	Interventions/mode of delivery	Measurement tools	Intervention components	Who provided	Intervention frequency and duration
Voogt et al. (2013)	Two-arm cluster RCT; The Netherlands; 73 classes; n = 609; 17.3 years (SD 1.3); 40.1% female; ethnicity NR; 16.6% attended preparatory secondary vocational education (similar to junior high school and a prerequisite for secondary vocational education); 83.4% attended secondary vocational education (equivalent of junior college education geared towards preparing students for skilled trades / entering the job market)[e]	Alcohol	Heavy drinking; weekly alcohol consumption; frequency of binge drinking	NA	INT: *What Do You Drink* (WDYD) brief web-based intervention	Online self-report survey	Part 1: Web-based intervention, screening of drinking behaviour and personalised feedback based on screening outcomes tailored to participant sex, alcohol intake and perceived social norms; online drinking scenarios and setting drinking goals. Part 2: goal setting, action planning, and reinforcing drinking refusal self-efficacy	Online; self-guided	One 20-min session

Table 1 (continued)

	Study design and key sample demographics	Targeted risk behaviours	Primary outcomes	Secondary outcomes	Interventions/mode of delivery	Measurement tools	Intervention components	Who provided	Intervention frequency and duration
Wright et al. (2013)	Two-arm RCT; USA; one urban paediatric outpatient clinic; n = 50 obese children (BMI percentile ≥ 95th) & their parents; child 10.3 years (SD 1.1), 42% female; with 72% African-American, 73.5% lower income, 52.5% high-school educated parents	Diet, screen-time	Consumption of kilocalories (kcal/wk); fat, fruits and vegetables (servings/day);	Television time hrs/wk; BMI	*Healthy Eating and Activity Today* (HEAT) parent–child telephone counselling intervention	Objective height and weight; interviewer administered questions and assessment (Block Dietary Data Systems Kids Food Screener version 2, Block 2007 Fat, Sugar, Fruit, and Vegetable screener (for parents), Youth Risk Behaviour Survey and a 12-item proxy measure (completed via parents) assessing child screen time and recreational activities); paper survey for parent and child individually self-report acceptability and feasibility of HEAT	Separate parallel telephone counselling via automated interactive voice response (IVR) system for children and parents. Sessions included tailored questions, quizzes and feedback based on participants' response to IVR system; participants' responses stored in system to inform subsequent calls; vignettes and testimonials to support content using age and gender appropriate voice actors; child or parent guidebook to support calls (call topics, space to write weekly goals, track weight and foods consumed, list of community resources for PA and recreation and alternatives to TV watching); reminder call from research assistant if participants not making calls to IVR system. Data captured in calls combined with child's electronic health record (EHR) to be used by primary care clinician in FU visit with child Children: IVR topics included increasing consumption of green foods (low-calorie, nutrient dense) and reducing consumption of red foods (high-fat and/or high-calorie), and reducing screen time. Objectives included learning Traffic Light diet, rules, self-monitoring weight, food, screentime, and setting goals and rewards Parents: IVR goals included: (1) having a healthy home i.e. no junk food, more green and yellow foods, creating rules related to healthy eating and screen time, asking auxiliary household members to support healthy changes; (2) good role modelling; (3) respectful child-parent relationship; (4) praising and encouraging child healthy behaviours	HEAT: Telephone—automated interactive voice response system using text-to-speech EHR component: Physicians, nurses and clinical staff at the paediatric clinic	Twice a week for 12-weeks telephone counselling for parent and child, separately; EHR component: One session at 1-month post-intervention follow-up

Table 1 (continued)

	Theoretical basis	Tailoring	Modifications	Co-designed	Comparison group	Follow-up	Process outcomes	How well/process outcomes	Intervention effects
Chai et al. (2021)	CALO-RE taxonomy	Both intervention groups could access the Back2Basics Family website for the entirety of the 12-week intervention, and received two 20-min telehealth consultations with a dietician in weeks 1 and 4 of the intervention. Only the telehealth and SMS group received SMS messages, in 4-weekly rotations of decreasing frequency to determine whether they enhanced the intervention	Back2Basics website content was modified from the Hunter and Illawarra Kids Challenge Using Parent Support (HIKCUPS) community-based study. HIKCUPS was previously modified to socio-economically disadvantaged areas based on focus groups with families	Yes; Online survey responses from 75 parents informed the development of additional topics and SMS content. Subsequently, 28 experts (family health researchers, health behaviour researchers, dieticians, or nutrition academics) and 20 parents (73% low-middle SES) reviewed the SMSs via an online evaluation survey	Waitlist control	Baseline, post-intervention (12-weeks) Retention at 12 weeks was 78% (n = 36 families; 21 intervention, 15 control) Intervention (n = 31 families): 3 families withdrew within the first month due to lack of time and 7 were lost to follow-up Control (n = 15 families): all control families completed week 12 assessments	Intervention fidelity; acceptability and adherence The control group completed process evaluation survey at week 24	Most families (96% n = 44 of 46 families) attended 1st telehealth consultation, and 78% (n = 36 of 46 families) attended 2nd telehealth consultation in week 4 of intervention Most families (77%; n = 23) logged into the B2BF website at least once, (80%; n = 24) visited their respective Facebook group at least once, and 100% received the SMS Only 4% (n = 2 of 46 families) of families required support with installing the videoconferencing software "Scopia" 87–100% of families reported the program was easy to use, 93% said it improved their family/child's eating habits and 91% stated wanting to continue using the program and would recommend it to other families Nine (60%) of control families completed the process evaluation survey at week 24	Significant intervention effects for primary outcomes: INT1 total energy intake was 2835 kJ less than control (p = 0.026); and percentage energy (%E) in INT2 increased 11% from nutrient-rich food e.g. fruit (p = 0.045) and decreased 11% from energy-dense, nutrient-poor food (p = 0.038) compared to control group No significant intervention effects for any of the secondary outcomes
Cremers et al. (2015)	I-Change model	INT1 and INT2 received tailored feedback messages based on their responses to questionnaire responses at baseline, 12- and 25-months post-baseline	The original paper-based *Octopus* intervention was modified to be a web-based, computer-tailored intervention	Yes; Group interviews with 87 students aged 10–12 years informed the development of the name, colour scheme and design of the *Fun Without Smokes* intervention and website	Assessment only	Baseline, 12- and 25-months after baseline. Attrition was 33.21% (n = 1067/3213) at 12-month follow-up, and 53.84% (n = 1730/3213) at 25-month follow-up	NR	NR	There were no significant in intervention effects for INT1 or INT2 compared to control on any of the primary or secondary outcomes at any of the follow-up time points

Table 1 (continued)

	Theoretical basis	Tailoring	Modifications	Co-designed	Comparison group	Follow-up	Process outcomes	How well/process outcomes	Intervention effects
Davis et al. (2016)	Cognitive behavioural theory	NR	The original *Healthy Hawks* intervention was modified to rural family population needs	Yes; focus groups with 21 rural parents of overweight or obese children informed the modification of the *Healthy Hawks* intervention manual to include the unique barriers to achieving healthy child weight status, such as lack of weight loss resources in their community and information on self-esteem for larger body sizes	INT1 vs. INT2	Baseline, 8-weeks, and post-intervention (8 months). Attrition was 10%	Telemedicine and telephone session attendance; Intervention feasibility measured on a 10-point scale with 10 equalling the highest satisfaction	Overall, 89.4% of participants attended intervention meetings. INT2 had slightly higher completion (90.82%) than INT1 (88.41%) Satisfaction following the intervention did not significantly differ between INT1 ($M=7.77\pm1.58$) and INT2 ($M=8.33\pm1.63$). 95.74% of INT1 participants reported finding the intervention helpful in improving their child's health, compared to 93.55% of INT2 participants. Participants in both intervention groups reported being extremely satisfied with the group leaders ($M=8.93\pm1.55$), handouts ($M=8.63\pm1.39$), included topics ($M=8.31\pm1.74$) and level of feedback provided ($M=8.13\pm1.81$)	There were no significant differences in groups by time for any diet or nutrition variables or for physical activity ($t=2.28$, $p=0.05$) Child BMI-z scores were not significantly different at 8-weeks follow-up ($t=0.91$, $p>0.05$) or at 8-month follow-up ($t=0.13$, $p>0.05$) There were no significant differences in groups by time at post-intervention for the CBCL, BPFAS, or obesity related quality of life measures

Table 1 (continued)

	Theoretical basis	Tailoring	Modifications	Co-designed	Comparison group	Follow-up	Process outcomes	How well/process outcomes	Intervention effects
Frenn et al. (2003)	Transtheoretical model, health promotion model	The intervention was tailored to individuals' stage of change in the Transtheoretical Model. For those in the "precontemplation", and "contemplation" stages, intervention sessions were centred on increasing awareness of eating behaviour and exercise, advantages of a diet low in fat and exercising and barriers to engaging in these behaviours For individuals in the "preparation", "action", and "maintenance" stage of change, the intervention was centred on preparing them to become peer role models that could lead healthy food and exercise labs under supervision from research staff	NR	No	Education as usual	Baseline, and post-intervention (1 year). Retention NR	NR	NR	Mean percentage dietary fat was not significantly different at post-intervention between intervention (31%) and control group (32%). Participation in internet sessions was associated with a decrease in percentage dietary fat MVPA reduced in both intervention and control groups, however, the reduction was smaller in the intervention group (-8.58 min) compared to the control (-37.61 min; $p=0.024$). However, the intervention significantly increased MVPA among the lowest income for all races except Native Americans ($p=0.04$)

Table 1 (continued)

	Theoretical basis	Tailoring	Modifications	Co-designed	Comparison group	Follow-up	Process outcomes	How well/process outcomes	Intervention effects
Frenn et al. (2005)	Transtheoretical model, health promotion model	Personalised feedback depended on participants' stage of change according to Transtheoretical Model	NA	No	Education as usual	Baseline, and post-intervention (1 month). 77% retention	Participation in the intervention (participants completing > 50% of intervention modules included in the intervention group analyses)	12 participants did not complete 50% of the physical activity intervention sessions, however, their change in MVPA levels were not significantly different to the control ($t(13) = 1.53$, $p = .15$) 6 participants did not complete the diet intervention sessions, however, they percentage of dietary fat was not significantly different to the control ($t(16.6) = -1.843$, $p = .08$)	Among participants across all racial groups with the lowest income (eligible for free lunch) intervention was effective in decreasing dietary fat and increasing physical activity Dietary fat: Participants that completed > 50% of diet sessions ($n = 40$) decreased dietary fat from 30.7% to 29.9% $t(87) = 2.73$, $p = -.008$ PA: Participants ($n = 43$) that completed > 50% of physical activity sessions increased MVPA by 22 min, whereas the control group decreased by 46 min, $t(103) = -1.99$, $p = .05$

Table 1 (continued)

	Theoretical basis	Tailoring	Modifications	Co-designed	Comparison group	Follow-up	Process outcomes	How well/process outcomes	Intervention effects
Gustafson et al. (2019)	Social cognitive theory	Messages were tailored to participants dependent on how they responded (i.e. "got it" or "not yet") to the initial message sent on the Tuesday and Saturday	NR	Yes; Survey data from 432 adolescents aged 14–16 years in rural Kentucky and North Carolina that included information on their food environments informed the development of the GBBH intervention content	Waitlist control	Baseline, and post-intervention (8 weeks). Retention NR	NR	NR	There were no significant intervention effects on SSB intake and BMI at post-intervention follow-up Fruit and vegetable intake was significantly higher in the intervention compared to control group at post-intervention follow-up, with a mean difference 1.28 servings/day (95% CI 1.11 – 1.48). Within group analysis reported the intervention group increased 0.71 servings/day compared to a decrease of 1.52 servings/day in the control, however, results were not significant There were no significant between group differences in purchasing habits, however, there were significant increases in fruit and vegetable purchases over 7-days (2.55 purchases/week, 95% CI 0.69 – 4.42), healthy snack purchases (1.81 snacks/day 95% CI 0.68 – 2.94) and water or no calorie beverages (0.87 cal/day 95% CI 0.18 – 1.56) within the intervention group Within the intervention group, there was a significant change in home availability of junk food ($p=0.08$), with an increase of 8% of junk food never being available, and a reduction of 4% and 5% of junk food being sometimes or always available, respectively. Within the control group, there was a significant decrease of 13% in fruit and vegetables always being available, and a 6% and 7% increase in sometimes or never available, respectively ($p=0.02$). No other within group analyses were significant. Between group analyses report a difference for home availability of fruit and vegetables ($p=0.03$), vegetables servings at dinner ($p=0.03$), junk food ($p=0.01$) and soda ($p=0.05$) Compared to the control group, the intervention group reported higher odds of having high self-efficacy for eating vegetables (OR 1.59, 95% CI 1.19 – 2.13), and goal setting for all dietary goals (Fruit—OR 1.52, 95% CI 1.18 – 1.95); (Vegetable—OR 1.75, 95% CI 1.19 – 2.58); and (Sugar-free beverage—OR 1.94, 95% CI 1.18 – 3.27)

Table 1 (continued)

	Theoretical basis	Tailoring	Modifications	Co-designed	Comparison group	Follow-up	Process outcomes	How well/process outcomes	Intervention effects
Hongthong and Areesantichai (2016)	Social learning theory	NR	NR	Yes; focus groups with students and teachers guided the development of the *PALMSS* intervention	Education as usual	Baseline, post-intervention (4 weeks after baseline), 1-month, 3-month and 6-month post-intervention. Retention NR	NR	NR	Peer drinking and GPA were significantly higher in the intervention compared to control group. After peer drinking and GPA were adjusted for, alcohol knowledge scores were significantly higher in the intervention compared to control group at 6-month follow-up ($F(1,146) = 199.11$, $p = < 0.001$). However, within-subject analysis reported non-significant result of intervention on changes in knowledge scores over the four follow-up periods ($F(3,438) = 1.87$, $p = 0.13$)
Lubans et al. (2016) and Smith et al. (2014)	Social cognitive theory, self-determination theory	Motivational messages through the *ATLAS* app were tailored to how the student responded to their reasons for being motivated to be physically active at the start of the intervention	The *Physical Activity Leaders* (PALS) pilot study informed the design of the *ATLAS* study to include increased diversity of activities and increased movement skill development	No	Education as usual	Baseline, post-intervention (8-months) and 10-months post-intervention (18-months from baseline). Retention: 81.2% (n = 293) at 8-months follow-up, and 73.7% (n = 266) at 18-months follow-up	Intervention implementation; school sport session fidelity; attendance at sessions; participant engagement with app and pedometers; intervention satisfaction	Across intervention schools, 79% ± 15% implemented the *ATLAS* sport sessions and 64% ± 40% implemented the lunchtime mentoring sessions Adherence to the *ATLAS* sport session structure across 4 observation periods was 61%, 58%, 90%, and 96% 65% of participants attended ≥ 70% of *ATLAS* sport sessions, however, only 44% attended at least two-thirds of lunchtime sessions 63% of participants used the ATLAS app and 25% used the ATLAS website. 70% of participants used the goal setting function to increase physical activity or reduce screen-time. 62% monitored resistance training via the ATLAS app, and 49% monitored pedometer steps and fitness challenge results On a scale of 1 to 5, with 5 being the highest, a high proportion of participants were satisfied with *ATLAS* (mean: 4.5 ± 0.7) and enjoyed the sport sessions (mean: 4.5 ± 0.7). Satisfaction scores for the lunchtime sessions were lower (mean: 3.7 ± 1.0). Nearly 50% of participants agreed or strongly agreed the "push prompts" reminded participants to consume less SSBs and reduce screen-time. 44% agreed or strongly agreed that they enjoyed using the *ATLAS* app. Satisfaction with *ATLAS* was high among teachers (mean: 4.4 ± 0.5), including enjoying professional development workshop 1 (mean: 5.0 ± 0.0) and 2 (4.9 ± 0.4)	SSB intake was significantly less in the intervention group (mean: = -0.6 ± 0.26 glass/d; $p = .01$) compared to control at 8-month follow-up. However, this effect was not sustained at 18-month follow-up There was a significant intervention effect on screen-time (mean: −30 ± 10.08 min/d; $p = .03$), muscular fitness (mean: 0.9 ± 0.49 repetition; $p = .04$), and resistance training skills (mean: 5.7 ± 0.67 units; $p < .001$) At 18-months follow-up there were only intervention effects onscreen-time, resistance training skill competency and motivational regulations for school sport 18-month follow-up group-by-time analyses showed an interaction effect for screen-time (mean = − 32.2 min/day, 95% CI = −53.6 to − 10.8, p = .003), resistance training skill competency (mean = 5.9 units, 95% CI = 4.5 to 7.3, p < .001), intrinsic, identified, introjected and external regulations range of adjusted differences between groups between 0.40 units to 0.56 units, p < 0.05 for all

Table 1 (continued)

	Theoretical basis	Tailoring	Modifications	Co-designed	Comparison group	Follow-up	Process outcomes	How well/process outcomes	Intervention effects
Martinez-Montilla et al. (2020)	I-Change model	The messages delivered to participants through the *Alerta Alcohol* cartoon stories depended on which main character the participant chose	The original *Alcohol Alert* intervention developed in The Netherlands was culturally modified to the Spanish context to reflect differences in cultural issues related to alcohol consumption, knowledge and risk perception of alcohol consumption, and motivational factors (e.g. attitude and social influences)	Yes; 14 focus groups with adolescents aged 16 to 18 years, in addition to focus groups with fathers / mothers, and a Delphi expert group informed the development of *Alerta Alcohol* content including character stories adapted to gender and age and tailored health messages	Waitlist control	Baseline, and 4-months after baseline. Attrition was 50.92% (n = 612) at 4-months follow-up	Intervention adherence; acceptability and satisfaction	Of the 742 participants that completed the first session, 461 (62.1%) completed the second, 350 (47.2%) completed the third session at school. 23 (3.1%) and 8 (1.1%) completed the fourth and fifth sessions at home Of the 295 participants that completed process evaluation questions, 150 (50.8%) said the sessions were too long. 223 (76.1%) reported the advice content was credible, 185 (63.1%) said it was understandable, 185 (63.1%) said it was useful, and 177 (60.0%) said it was interesting. 203 (68.8%) were satisfied with *Alerta Alcohol*, 155 (52.9%) reported intention to use it again, and 184 (62.8%) would recommend it to someone else	With the exception of heavy episodic drinking in favour of the intervention (OR 9.129, 95% CI 1.107–75.259, $p = .04$), there were no significant between group intervention effects on alcohol consumption outcomes Logistic regression analyses showed that at follow-up, compared to participants of high family affluence, participants with medium family affluence were more likely to binge drink (OR 3.365, 95% CI 1.058–10.704, P = .04), and participants of low family affluence were more likely to have consumed any alcohol (OR 1.801, 95% CI 3.289–0.987, P = .06)

Table 1 (continued)

	Theoretical basis	Tailoring	Modifications	Co-designed	Comparison group	Follow-up	Process outcomes	How well/process outcomes	Intervention effects
Murry et al. (2019)	NR	NR	Based on ethnographic research on the availability of computers in the local communities, the original *Strong African American Families Program* (SAAF) intervention was modified to be delivered via computer for rural African American families	Yes; interviews with 40 interviewers (African American community members) informed the development and refinement of study measures and procedures	Non-interactive content (hard-copy version of intervention content)	Baseline, post-test [M = 14.5 (4.4) months after pre-test] and long-term follow-up [M = 22.6 (3.7) months after post-test] Retention: 337 (80%) at post-test follow-up, and 165 (39%) at long-term follow-up	INT2 fidelity assessed via random selection of videotaped sessions—interrater reliability > 80% for parent, youth and family sessions, and fidelity to curriculum > 80%	NR	Risk behaviour among youth significantly decreased over time in INT1 (β = −.17; 95% CI = −31 to −.04; p = .04), however, was not significant in INT2 (β = −.05; 95% CI = −.20 to .11; p = .58) Behavioural intentions to engage in risk behaviours significantly decreased over time in INT1 (β = −.12; 95% CI = −.20 to .01; p = .04). However, affiliation with deviant peers significantly increased over time in INT2 (β = −.16; 95% CI = .06 to .27; p = .002)

Table 1 (continued)

	Theoretical basis	Tailoring	Modifications	Co-designed	Comparison group	Follow-up	Process outcomes	How well/process outcomes	Intervention effects
Nollen et al. (2014)	Behaviour change principles including goal setting, self-monitoring and cues to action	NR	NR	Yes; important themes were developed in four meetings with a 12-member community advisory board including staff members from the Young Women's Christian Association (YWCA) of Greater Kansas City, parents, teachers, health care professionals, and professionals from other organisations promoting health and wellness among adolescent girls. Two focus groups with a 15-member student advisory board gave feedback on using personal digital assistant (PDA) technology to deliver an intervention delivery, and the development of future intervention phases/ prototypes	Hardcopy manual version of intervention content without prompts to use, action cues or a reward system	Baseline, weeks 4, 8 and 12 of intervention Retention was 86.2% at week 12 follow-up (n = 44). 7 lost to follow-up (3 intervention, 4 control)	Intervention enjoyment and use	Participants engaged with the program on 63% of days, answered 42% of prompts, and earned approximately 23.9 songs Intervention had a mean enjoyment score of 4.5 (SD 0.9), with favourite components being the songs (68.2%), and goal setting (36.4%). The least liked component was the reminder prompts (31.8%) Program use was associated with SSB ($r = 0.50$, $p = 0.01$), however, not significant for fruit and vegetable servings or screen time. At 8-week follow-up, participants responding to more prompts had greater reductions in SSBs compared to those responding less (mean difference = -0.31 daily servings)	Within group analyses reported the intervention group increased fruit and vegetable consumption ($p = 0.08$) and decreased SSBs ($p = 0.09$). Between group analyses reported the intervention ate 1 more servings of fruit and vegetables ($p = 0.13$) and 0.35 less servings of SSBs ($p = 0.25$) with Cohen's $d = 0.44$, and -0.34, respectively No significant intervention effects on screen time or BMI

Table 1 (continued)

	Theoretical basis	Tailoring	Modifications	Co-designed	Comparison group	Follow-up	Process outcomes	How well/process outcomes	Intervention effects
Tripicchio et al. (2017)	N.R. Behaviour change strategies included goal setting, feedback and personal tailoring and motivational interviewing	INT2: FITNET provided personal tailoring of physical activity INT3: health coaching Skype sessions were individually tailored to families	INT2 & INT3 were added to the existing Healthy Hawks intervention (FBBG)	No	Pre-post within group comparisons Between group comparisons	Baseline and post-intervention (12 weeks). Retention: FBBG 66.7%, INT2 80%, and INT3 78.3% ($\chi2=1.2$, $p=0.56$)	Weekly FBBG attendance; acceptability and use of FITNET and telemedicine sessions	Out of the 12 weekly FBBG sessions, INT1 attended the most (10.3 ± 1.11), followed by INT3 (9.6 ± 2.0) and INT2 (9.4 ± 2.0) FITNET total usage in minutes was significantly higher among INT3 (425.4 ± 275.6) than INT2 (225.2 ± 148.4) ($F=5.6$, $p=0.02$) All of INT3 completed at least 1 Skype session, and 44.5% completed 5 sessions ($M=3.4 \pm 1.7$) Overall, acceptability of FITNET and Skype was rated highly FITNET: Among those that completed the FITNET acceptability survey, participants in INT2 reported intention to use FITNET post-intervention if available, and INT3 reported FITNET was helpful for increasing and maintaining PA Skype: 90% of INT3 parents said the sessions were "very" or "extremely" helpful for their children to reach health goals ($M = 4.3 \pm 0.7$), and 100% said they were equally as helpful for them to reach personal health goals ($M = 4.4 \pm 0.5$). All parents reported they were "very" or "extremely" enthusiastic to recommend the sessions to other families ($M = 4.8 \pm 0.5$)	INT3 was the only group with significant changes in BMI-z post-intervention (β= -0.09(0.02), $p<0.001$). INT1: β= -0.05(0.04), $p=0.25$; INT2: β= -0.006(0.06), $p=0.92$ Telemedicine use was significantly associated with BMI-z reduction (β= -0.04(0.01), $p=0.01$)
Voogt et al. (2013)	I-Change model, motivational Interviewing principles	In part 1 of intervention, the participant received personalised feedback based on their sex, alcohol intake and perceived social norms	The original WDYD intervention was slightly modified in terms of usability (i.e., use of language) to target adolescents and young adults between the ages of 15–20 years with a low educational background	No	Assessment only	Baseline, and 1- and 6- months follow-up Attrition rates were 35.5% (n=216, 134 in the intervention condition and 82 in the control condition) and 54.0% (n=329, 188 in the intervention condition and 141 in the control condition) at one and six months follow-up	NR	NR	There were no significant intervention effects on weekly alcohol consumption, heavy drinking and frequency of binge drinking at 1- and 6-months follow-up. The results were replicated in a completers-only analysis with the exception of frequency of binge drinking at 1-month which showed that 55.7% of the intervention drank 5 + glasses compared to 66.7% in the control ($OR=0.85$; $CI=0.73$ to 0.98; NNT = 11; $p=0.03$) Gender, age, educational level and readiness to change had no significant moderating effect between the intervention and alcohol outcomes at any follow-up period

Table 1 (continued)

	Theoretical basis	Tailoring	Modifications	Co-designed	Comparison group	Follow-up	Process outcomes	How well/process outcomes	Intervention effects
Wright et al. (2013)	Social cognitive theory	Tailored feedback was provided to participants based on their responses to the IVR system questions	NR	No	Waitlist control	Baseline and 3-months post baseline; Retention was 86% at follow-up (intervention n = 21/24 [87.5%]; control n = 22/26 [84.6%])	Feasibility and acceptability of intervention	Feasibility of IVR: 17/21 children (81%) called the IVR system at least once. The mean number of total calls was 9.0 (averaging 6.2 for the education and 2.8 for the monitoring calls) Acceptability of IVR: Most children reported HEAT was easy to use, helpful, trustworthy, designed appropriately for people like them, and supported them eat healthy foods. Only 35% said it supported them reduce screen time. 83% of children said they would recommend HEAT to a friend, 82% reported liking HEAT as it could be used at home, 59% reported liking HEAT as it could be accessed over the phone, and approximately 50% reported preferring using HEAT via a website	No significant between group differences on adolescents' total consumption of kilocalories (kcal/wk), fat, fruits and vegetables (servings/day) Television time was significantly less among the intervention compared to control at follow-up (mean difference: -2.0 h/d; p = 0.05) There were no intervention effects on BMI

[a]The National School Lunch Program in the US determines the eligibility for free lunch based on a student's SES and is a proxy for low SES

[b]PALMSS is an abbreviation of the six core components of the program: *P* peer, *A* alcohol knowledge, *L* low-risk drinking, *M* media-influence, *S* social drinking and S = self-efficacy

[c]ATLAS is an abbreviation for the multicomponent obesity prevention intervention "Active Teen Leaders Avoiding Screen-time"

[d]Adolescent risk behaviours (including substance use and sexual risk behaviour) were conceptualised as a composite risk score

[e]In The Netherlands higher education (bachelor/master) are called Higher Professional Education and Scientific Education

(Gustafson et al., 2019) at post-intervention; decreased SSB consumption at post-intervention (8-months) but not 18-month follow-up (Lubans et al., 2016; Smith et al., 2014); reduced total energy intake in a telehealth only-based intervention group, and percentage energy increase of nutrient-rich food e.g. fruit and decrease of nutrient-poor food in a telehealth plus SMS group (Chai et al., 2021).

Three trials reported non-significant between group differences on: fruit and vegetable consumption and SSB intake compared to control (Nollen et al., 2014); daily intake of calories, percent calories from fat, fruit and vegetables, SSBs, and nutrient-poor foods between a telephone-based to telemedicine-based intervention (Davis et al., 2016); and adolescents total consumption of kilocalories (kcal/wk), fat, fruits and vegetables (servings/day) compared to control (Wright et al., 2013).

Finally, two trials (Frenn et al., 2003, 2005) assessed intervention effects on percentage dietary fat, with one reporting no significant difference between intervention and control groups at post-intervention (1-year) (Frenn et al., 2003).

Alcohol and Tobacco Use

Of the three trials assessing alcohol consumption and tobacco smoking, one trial (Martinez-Montilla et al., 2020) reported a reduction in heavy episodic drinking at 4-months post-baseline among the whole study sample. Compared to participants of high family affluence, those of medium family affluence were significantly more likely to binge drink, and those of low family affluence were more likely to have consumed any alcohol (although results were not significant $p=0.6$).

Two trials (Martinez-Montilla et al., 2020; Voogt et al., 2013) found no significant intervention effects on binge drinking, any or weekly alcohol consumption,—although one (Voogt et al., 2013) conducted analysis on participants that completed the intervention only and reported a significant reduction in binge drinking at 1-month follow-up compared to control –, and another (Cremers et al., 2015) found no intervention effects on smoking behavior.

Secondary Outcomes

Secondary outcomes data reported in each trial is presented in Table 1. Five trials assessed intervention effects on moderate to vigorous physical activity (MVPA) (Chai et al., 2021; Davis et al., 2016; Frenn et al., 2003, 2005; Lubans et al., 2016; Smith et al., 2014), however, only one trial reported a significant increase in MVPA (Frenn et al., 2005). Three trials assessed intervention effects on screen-time (Lubans et al., 2016; Nollen et al., 2014; Smith et al., 2014; Wright et al., 2013), with two reporting significant reductions (between -30 min/day to -2 h/day) in screen-time (Lubans et al., 2016; Smith et al., 2014; Wright et al., 2013).

One trial (Murry et al., 2019) conceptualized adolescent risk behaviors (substance use and sexual risk) as a composite risk score and found the computer-based intervention was associated with a significant decrease in risk behaviors and intentions to engage in risk behaviors (including alcohol and tobacco use) over time. Contrastingly, another trial (Cremers et al., 2015), reported no significant reduction in tobacco smoking intentions.

In the one trial (Hongthong & Areesantichai, 2016) that assessed intervention effects on alcohol knowledge, it reported significantly increased alcohol knowledge scores in the intervention group compared to control group at 6-month follow-up after adjusting for peer drinking and GPA.

Finally, seven trials (Chai et al., 2021; Davis et al., 2016; Gustafson et al., 2019; Lubans et al., 2016; Nollen et al., 2014; Smith et al., 2014; Tripicchio et al., 2017; Wright et al., 2013) assessed intervention effects on BMI, however, only one trial (Tripicchio et al., 2017) was associated with reduced BMI-z scores at post-intervention (12-weeks) among a app and telemedicine-based intervention group. However, between group differences were not significant.

Factors Associated with Intervention Effectiveness

For studies with significant intervention effects on primary outcomes (Chai et al., 2021; Gustafson et al., 2019; Lubans et al., 2016; Martinez-Montilla et al., 2020; Smith et al., 2014; Voogt et al., 2013), intervention length ranged from one 20-min session to 8-months, included personalized feedback to participants, and Social Cognitive Theory was most common when targeting poor diet, and I-Change Model was most common when targeting alcohol use.

Generally, studies reporting non-significant intervention effects on primary outcomes (Cremers et al., 2015; Davis et al., 2016; Frenn et al., 2003; Nollen et al., 2014; Wright et al., 2013) were either delivered via telephone or telemedicine, or did not provide personalized feedback, with intervention length ranging from 12-weeks to 1-year. There were no clear differences in intervention effects on primary outcomes when comparing programs that were co-designed (Chai et al., 2021; Cremers et al., 2015; Davis et al., 2016; Gustafson et al., 2019; Martinez-Montilla et al., 2020; Nollen et al., 2014) versus those that were not (Frenn et al., 2003, 2005; Lubans et al., 2016; Smith et al., 2014; Voogt et al., 2013; Wright et al., 2013).

Intervention effects on primary outcomes for trials specifically designed for disadvantaged adolescents (Chai et al., 2021; Davis et al., 2016; Frenn et al., 2003; Gustafson et al., 2019; Lubans et al., 2016; Nollen et al., 2014; Smith et al., 2014; Voogt et al., 2013) versus those that conducted subgroup analyses (Cremers et al., 2015; Frenn et al., 2005;

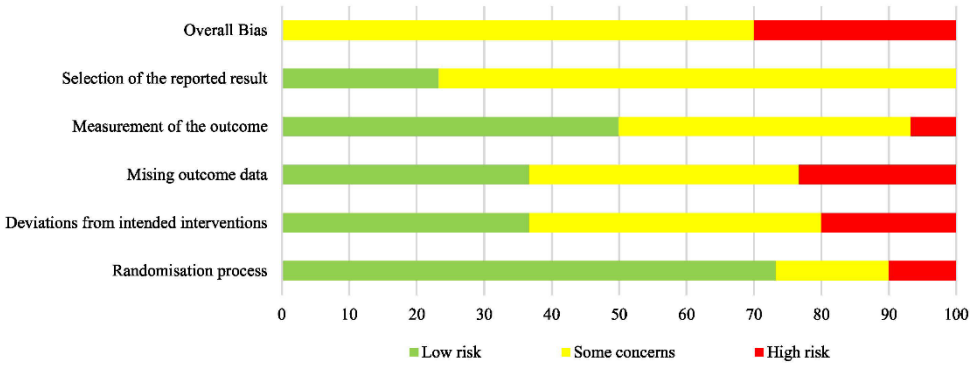

Fig. 2 Overall risk of bias assessment for included studies

Martinez-Montilla et al., 2020; Wright et al., 2013) were similar, with four (Chai et al., 2021; Gustafson et al., 2019; Lubans et al., 2016; Smith et al., 2014; Voogt et al., 2013) of ten trials, and one (Martinez-Montilla et al., 2020) of four, reporting significant intervention effects, respectively.

Three trials reported participants' participation in the intervention was associated with higher reductions in dietary fat and increased physical activity (Frenn et al., 2005), decreased BMI-z scores (Tripicchio et al., 2017) and SSB consumption (Nollen et al., 2014). Of the six trials (Davis et al., 2016; Lubans et al., 2016; Martinez-Montilla et al., 2020; Nollen et al., 2014; Tripicchio et al., 2017; Wright et al., 2013) that assessed participant satisfaction with the intervention, generally interventions were rated highly. Participant retention did not appear meaningfully different between interventions reporting significant results versus those that did not, and only two studies (Cremers et al., 2015; Martinez-Montilla et al., 2020) reported participant retention below 50% at post-intervention follow-up.

Risk of Bias

A summary of the overall risk of bias assessment for included papers is shown in Fig. 2. Of the 15 included articles, seven studies were rated as having high risk of overall bias for at least one outcome (Chai et al., 2021; Cremers et al., 2015; Frenn et al., 2003; Martinez-Montilla et al., 2020; Nollen et al., 2014; Smith et al., 2014; Tripicchio et al., 2017), and several studies were rated as having unclear overall risk of bias for at least one outcome (Chai et al., 2021; Davis et al., 2016; Frenn et al., 2005; Gustafson et al., 2019; Hongthong & Areesantichai, 2016; Lubans et al., 2016; Murry et al., 2019; Smith et al., 2014; Voogt et al., 2013; Wright et al., 2013). These ratings were predominantly driven by missing outcome data (i.e. not examining differences between participants lost to follow-up and those that completed follow-up assessments) and deviations from intended interventions (i.e. blinding often was not possible and in some studies intention-to-treat analysis was not employed). Furthermore, most studies failed to reference a published protocol, and were therefore rated has having an unclear risk of selective reporting of the result.

Discussion

Chronic disease burden disproportionately affects disadvantaged adolescents including those from low socioeconomic and geographically remote backgrounds. A critical and cost-effective approach towards reducing the risk of experiencing chronic disease burden across the lifetime, is preventing lifestyle risk behaviors such as poor diet, alcohol use, tobacco smoking and vaping in adolescence, that is ideally prior to their onset and entrenchment. There is considerable evidence to support the efficacy of universal eHealth interventions among adolescents in delaying or preventing modifiable risk behaviors. This is the first study, however, to systematically review the effectiveness of eHealth interventions targeting adolescents living in geographically remote and/or of lower socioeconomic contexts in preventing poor diet, alcohol use, tobacco smoking and vaping.

As adolescence is a key formative period of development that can have lasting effects on future health, it is critical prevention interventions are delivered prior to the initiation and uptake of lifestyle risk behaviors that may lead to subsequent development of chronic disease in adulthood. Interestingly, this study found that although the age range of adolescents from disadvantaged backgrounds in included studies varied from 9 to 17 years, generally adolescents were older (average 14 years) in studies reporting significant intervention effects related to poor diet, alcohol and tobacco use (Chai et al., 2021; Gustafson et al., 2019; Hongthong & Areesantichai, 2016; Lubans et al., 2016; Martinez-Montilla et al., 2020; Murry et al., 2019; Smith et al., 2014; Voogt et al., 2013), compared to those that were not (average 11 years) (Cremers et al., 2015; Davis et al., 2016; Frenn et al., 2003, 2005; Nollen et al., 2014; Tripicchio et al., 2017; Wright et al., 2013). It appears that older adolescents are more receptive to eHealth interventions, which may be reflective of developing greater autonomy over their life (Spear & Kulbok, 2004). However, it is important that future longitudinal studies

assess the long-term effects of eHealth interventions across adolescence.

Another key point to consider with regard to interventions aimed at preventing lifestyle risk behaviors among disadvantaged adolescents, is delivering interventions that pay attention to contextual factors including socioeconomic status and geographic location as they may potentially influence the efficacy of programs. In this study, the distribution of studies was largely skewed towards focusing on adolescents of low socioeconomic backgrounds, and were predominantly aimed at preventing poor diet, followed by alcohol use and tobacco smoking. Relatively fewer studies targeted adolescents living in geographically remote areas. Only one study targeted adolescents of both low socioeconomic and geographically remote contexts in preventing alcohol use and tobacco smoking. No studies targeted vaping. Of the 15 articles that were analyzed in this study, five (Chai et al., 2021; Gustafson et al., 2019; Lubans et al., 2016; Martinez-Montilla et al., 2020; Smith et al., 2014; Voogt et al., 2013) reported significant intervention effects relating to improved dietary behaviors, and reduced alcohol use and tobacco smoking.

Of the six studies targeting adolescents of low socioeconomic backgrounds in preventing poor diet, only one was associated with decreased SSB consumption immediately post-intervention, however, intervention effects were short-lived with non-significant results at longer-term follow-up (Lubans et al., 2016; Smith et al., 2014). This finding is consistent with a recent review (Champion et al., 2019) of eHealth multiple health behavior change interventions. Although a smaller number of studies targeted adolescents living in geographically remote areas, two of the three were associated with improved dietary outcomes at post-intervention. Specifically, they reported significant intervention effects on increasing fruit and vegetable intake and percentage energy increase of nutrient-rich food, and decreasing total energy intake, energy-dense, nutrient-poor food percentage energy consumption (Chai et al., 2021; Gustafson et al., 2019). Considering these three studies together, they were most commonly guided by Social Cognitive Theory, were specifically designed for disadvantaged adolescents, and included personalized feedback to participants.

For studies not associated with improved dietary outcomes, it is possible that the lack of personalized feedback to participants hindered significant intervention effects in two studies (Davis et al., 2016; Nollen et al., 2014) or the study length and/or intervention dose was not sufficient to achieve larger effect sizes. For instance, in one study (Frenn et al., 2003) four 50-min internet-based lessons and one 50-min peer-led healthy snack session were delivered over one year. As the only assessment was conducted at post-intervention (1-year), there is the potential that intermediary intervention effects may have been missed, or lessons were too infrequent for participants to consolidate and apply learning. Given two of these studies found participation was associated with decreased percentage dietary fat (Frenn et al., 2003) and a larger reduction in SSB consumption (Nollen et al., 2014), this suggests additional modules were required. This is in line with a previous review of eHealth interventions targeting diet and physical activity, reporting greater intervention dose and utilization tended to improve health behavior change (Norman et al., 2007). Together these study components may have enhanced the effectiveness of the interventions. The overall risk of bias ratings for studies targeting poor diet included four studies as having high risk of overall bias on at least one outcome (Chai et al., 2021; Frenn et al., 2003; Nollen et al., 2014; Smith et al., 2014), and seven studies as having unclear overall bias on at least one outcome (Chai et al., 2021; Davis et al., 2016; Frenn et al., 2005; Gustafson et al., 2019; Lubans et al., 2016; Smith et al., 2014; Wright et al., 2013). Key domains contributing to these ratings included high risk of bias on deviations from intended interventions (due to blinding of intervention groups often not being possible) and missing outcome data, and unclear risk of bias for selective reporting of result.

Turning to studies that targeted alcohol use only, only two were included in this study and both were among adolescents of low socioeconomic backgrounds (Martinez-Montilla et al., 2020; Voogt et al., 2013). The first (Martinez-Montilla et al., 2020) found adolescents of lower family affluence were more likely to report consumption of any alcohol (although not significant $p=0.6$), and a significant association between family affluence and binge drinking at 4-months post-baseline among the whole study sample. The other (Voogt et al., 2013) reported significant intervention effects on binge drinking at 1-month follow-up among completers only. Although both studies were guided by the I-Change Model and included personalized messaging or feedback to participants, they differed in intervention dose and specific tailoring to disadvantaged adolescents. The first consisted of six one-hour sessions and conducted a subgroup analysis by family affluence. The second included one twenty-minute session and was specifically tailored to adolescents of low socioeconomic backgrounds. Interestingly, other universal studies have only found positive outcomes relating to the frequency of binge drinking at longer-term follow-up timepoints (i.e. 6- to 12-months, rather than immediately post-intervention) (Newton et al., 2010; Vogl et al., 2009) suggesting specifically tailored programs may yield more immediate enhanced program efficacy. The overall risk of bias was high for one (Martinez-Montilla et al., 2020) of these studies mainly due to missing outcome data (i.e. no sensitivity analysis) and measurement of the outcome (i.e. self-report), and unclear for the other (Voogt

et al., 2013) largely due to measurement of the outcome (i.e. self-report). As no studies targeted adolescents living in geographically remote backgrounds, these findings underscore a crucial need for future research, particularly as consumption of alcohol at risky levels tends to be higher among adolescents living in geographically remote areas (Marqués-Sánchez et al., 2020).

Considering interventions targeting tobacco use, none were targeted at adolescents living in geographically remote areas. This is concerning given tobacco smoking is generally higher among adolescents living in geographically remote areas than their counterparts (Warren et al., 2017). Unlike the abovementioned interventions targeting alcohol use reporting significant intervention effects that were also underpinned by the I-Change Model, the one study (Cremers et al., 2015) that targeted tobacco use only was not associated with a reduction of smoking behavior or intentions. Additionally, participant retention was less than 50% at post-intervention follow-up. This study (Cremers et al., 2015) was rated as having high overall risk of bias predominantly due to missing outcome data (i.e. significant differences in participants lost to follow-up). In view of these findings, consideration of alternative theories for tobacco use prevention interventions is warranted. For instance, eHealth interventions grounded in Social Cognitive Theory show promise in reducing tobacco smoking among adolescents with higher retention rates (Champion et al., 2013; Skov-Ettrup et al., 2014).

Concerningly, no studies targeted vaping. Although the proportion of adolescents initiating tobacco use is generally declining, the same cannot be said for vaping, and suggests the motivators for tobacco smoking and vaping are dissimilar among adolescents (Dutra & Glantz, 2014; Wills et al., 2016). Effective theories for interventions targeting tobacco use may not translate to those targeting vaping. Indeed, findings from a recent review recommended the delivery of prevention strategies targeting vaping be set-apart from tobacco use and underpinned by behavior change theories (Liu et al., 2020). Nevertheless, as no study has specifically targeted vaping among disadvantaged adolescents, future research is needed to examine the mechanisms of change in these behaviors.

Despite relatively few studies reporting significant intervention effects on primary outcomes, this review found positive effects on secondary outcomes in six studies including increased alcohol knowledge (Hongthong & Areesantichai, 2016) and MVPA (Frenn et al., 2005), decreased screen-time (Lubans et al., 2016; Smith et al., 2014; Wright et al., 2013), BMI-z scores (Tripicchio et al., 2017), and engagement and intentions to engage in risk behaviors (including alcohol and tobacco use) (Murry et al., 2019). These behaviors are important protective factors for chronic disease risk (Ezzati & Riboli, 2013), thus make a substantial contribution to supporting disadvantaged adolescents achieve improved future health outcomes. Moreover, several factors associated with intervention effectiveness (e.g. most effective theories for targeting specific health behaviors, delivery method and frequency, inclusion of personalized feedback) were identified in this review. However, it is worth highlighting that although effectiveness in intervention outcomes appeared similar between studies incorporating co-design versus those that did not, previous research has found interventions that have not been tailored to disadvantaged populations are associated with poor engagement and impact, and may contribute to greater health inequalities (Coupe et al., 2018). Co-design facilitates incorporation of the intended audience's experiences and perspectives into an intervention, and informs the type of content, delivery method, and key components to ensure its accessibility (Holly et al., 2022; World Health Organization, 2020). The importance of incorporating co-design into future interventions should be considered to adequately address the unique barriers disadvantaged adolescents experience and deliver effective and appropriate interventions.

The results indicate the need for future research on effective eHealth interventions among disadvantaged adolescents due to the paucity of studies identified and intervention effects on primary outcomes limited to those targeting poor diet and alcohol use only.

There are several strengths to this study. First, this study has provided a more up-to-date review of the literature on eHealth interventions, which is a rapidly developing area of research. For instance, compared to the Champion et al., (2019) systematic review that looked at eHealth interventions targeting poor diet, alcohol use and tobacco smoking, this systematic review differed in that it: utilized a targeted search to capture adolescents living in geographically remote and/or lower socioeconomic areas rather than focusing on the general population; included vaping as one of the target behaviors which is not included in the Champion et al., (2019) review; and includes research published up until 2022, with no date limits (Champion et al., 2019 included studies published from 2000 to 2017). Second, a team of experts in eHealth prevention interventions for young people contributed to this study by helping review, minimize bias and strengthening the analysis of findings. Third, a thorough, reproducible, and robust search strategy was employed to identify relevant studies. Fourth, this review provides critical information and analysis of important components of effective interventions, which has implications for the design and delivery of future eHealth interventions on this topic.

However, consideration of several limitations in this review is warranted. First, this study did not conduct a systematic search of grey literature, which may have limited

the diversity of relevant research studies included in this study as negative results are less likely to be published in peer-reviewed journals. However, grey literature may be prone to high risk of bias (e.g., conflict of interest when the same researcher conducts and evaluates a study) and is not restricted to the same reporting standards of peer-reviewed literature thus may omit important publication information (e.g. publication date, contributors). Second, any interventions framed as treatment rather than prevention were not eligible. As disadvantaged youth are 'higher risk', interventions aimed at helping adolescents who were already experiencing unhealthy behaviors (e.g. alcohol use disorder) and insight into alternative methods to reach disadvantaged adolescents may not have been identified in this study's analysis. Third, the overall risk of bias of included studies was unclear largely owing to authors failing to reference a published protocol, employing self-report as measurement for the outcome, missing outcome data for all participants, and deviations from the intended interventions. Fourth, despite the comprehensive search strategy, no studies targeting vaping met inclusion criteria. However, this is not unexpected considering vaping is a relatively newer behavior and the limited eHealth trials targeting vaping in the general population. Nevertheless, the potential of vaping exacerbating public health impact among disadvantaged adolescents, posits this is an important area for future research.

Conclusion

To address the disproportionately higher risk of chronic disease burden among disadvantaged adolescents including those of low socioeconomic or geographically remote backgrounds, prevention of lifestyle risk behaviors such as poor diet, alcohol use, tobacco smoking and vaping is critical. Despite evidence supporting the effectiveness of universal eHealth interventions in targeting these behaviors, there are gaps in the literature on whether eHealth interventions adequately serve disadvantaged adolescents. This is the first study to systematically examine and synthesize evidence on eHealth interventions targeting adolescents (aged 10–19 years) from disadvantaged backgrounds in preventing poor diet, alcohol use, tobacco smoking, and vaping. This study revealed that although eHealth interventions can be effective in targeting poor diet and alcohol use among disadvantaged adolescents, limited research in this area has been conducted with only 15 articles assessing 14 interventions included in this study's analysis. Ultimately, this represents a missed opportunity to meaningfully improve chronic disease risk profiles of disadvantaged adolescents, especially considering the growing evidence for the effectiveness of universal eHealth interventions that may delay or prevent the onset of lifestyle risk behaviors. Challenges remain in developing, delivering, and disseminating findings on effective evidence-based programs for the prevention of chronic diseases among disadvantage adolescents. More research on developing and evaluating effective eHealth interventions specific to adolescents from lower socioeconomic and geographically remote contexts is needed.

Appendix 1: Example Search Strategy

Database(s): MEDLINE (Ovid) search strategy from 1946 to Present.

Search Strategy: December 19, 2022.

Number	Search term
1	(eHealth or mhealth or electronic health or mobile health or telemedicine or telehealth).mp
2	Telemedicine/
3	1 or 2
4	Teen*.mp
5	Adolescen*.mp. or Adolescent/
6	Child*.mp. or Child/
7	Young adult*.mp. or Young Adult/
8	4 or 5 or 6 or 7
9	Diet*.mp. or Diet/
10	Nutrition.mp
11	Alcohol.mp
12	Alcoholic Beverages/
13	Smoking.mp. or Smoking/
14	Cigarette.mp. or Tobacco Products/
15	Vaping.mp. or Vaping/
16	9 or 10 or 11 or 12 or 13 or 14 or 15
17	Socioeconomic status.mp. or Social Class/
18	Socioeconomic Factors/ or low socioeconomic.mp
19	Poor.mp. or Working Poor/
20	Low income.mp
21	Rural.mp. or Rural Health/ or Rural Population/
22	(Regional or remote).mp
23	17 or 18 or 19 or 20 or 21 or 22
24	3 and 8 and 16 and 23

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Authors' Contributions All authors (LE, LAG, NN and KC) designed the study protocol; LE completed all database searches, article

screening, data extraction, risk of bias assessments, interpretation of results and drafted the initial manuscript; LAG contributed to screening a subset (approximately 9%) of included studies and resolved disagreements through consultation with all authors; NN contributed to screening a subset (approximately 9%) of included studies and resolved disagreements through consultation with all authors; KC contributed to screening a subset (approximately 9%) of included studies and resolved disagreements through consultation with all authors, reviewed the data extraction sheet and conducted independent risk of bias assessments. All authors reviewed the manuscript and approved the final version.

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Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Preregistration The study design, target analyses and synthesis of findings of this systematic review were prospectively registered with PROPSERO (CRD42021294119). Available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42021294119

Data Sharing All data collected for this study were obtained from published peer-review literature. Data extracted to inform this review are available on reasonable request from the corresponding author.

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Appendix B

Protocol paper for Chapter 3

Appendix B

Preface

This systematic review protocol has been published as:
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LE conceptualised the study with assistance from all authors. LE wrote the original manuscript. All authors reviewed and approved the final version for publication.

Protocol

eHealth Interventions Targeting Poor Diet, Alcohol Use, Tobacco Smoking, and Vaping Among Disadvantaged Youth: Protocol for a Systematic Review

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Abstract

Background: Chronic disease burden is higher among disadvantaged populations. Preventing lifestyle risk behaviors such as poor diet, alcohol use, tobacco smoking, and vaping in adolescence is critical for reducing the risk of chronic disease and related harms in adolescence and adulthood. Although eHealth interventions are a promising prevention approach among the general population, it is unclear whether they adequately serve adolescents from disadvantaged backgrounds such as those living in geographically remote or lower socioeconomic areas.

Objective: This is the first systematic review to identify, evaluate, and synthesize evidence for the effectiveness of eHealth interventions targeting adolescents living in geographically remote or lower socioeconomic areas in preventing poor diet, alcohol use, tobacco smoking, and vaping.

Methods: A systematic search will be conducted in 7 electronic databases: the Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, PROSPERO, MEDLINE (Ovid), Embase (Ovid), Scopus, and PsycInfo (Ovid). The search will be limited to eHealth-based experimental studies (ie, randomized controlled trials and quasi-experimental studies) targeting diet, alcohol use, tobacco smoking, and vaping among adolescents (aged 10-19 years). Eligible studies will be those reporting on at least one marker of socioeconomic status (eg, social class, household income, parental occupation status, parental education, and family affluence) or geographical remoteness (eg, living in rural, regional, and remote areas, or living outside major metropolitan centers). One reviewer will screen all studies for eligibility, of which 25% will be double-screened. Data will be extracted and summarized in a narrative synthesis. Risk of bias will be assessed using the Cochrane Revised Risk of Bias Tool.

Results: As of December 2021, the title and abstract screening of 3216 articles was completed, and the full-text review was underway. The systematic review is expected to be completed in 2022.

Conclusions: This systematic review will provide an in-depth understanding of effective eHealth interventions targeting poor diet, alcohol use, tobacco smoking, and vaping among adolescents living in geographically remote or lower socioeconomic areas and the factors that contribute to their effectiveness. This in turn will provide critical knowledge to improve future interventions delivered to these populations.

Trial Registration: PROSPERO CRD42021294119; https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=294119

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KEYWORDS

eHealth; adolescent; health promotion; diet; alcohol; smoking; vaping; socioeconomic status; remoteness; rural; disadvantage

Introduction

Chronic disease burden is considerably higher among disadvantaged populations such as those living in lower socioeconomic or geographically remote areas [1-6]; therefore, disadvantaged adolescent populations may be vulnerable to experiencing greater chronic disease burden in adulthood than their counterparts. Socioeconomic status is an indicator of an individual's or group's social and economic position within society and is generally associated with access to resources and health outcomes [7]. In Australia, geographically remote refers to areas outside of major cities, classified in order of remoteness and decreasing level of accessibility to services as *inner regional*, *outer regional*, *remote*, or *very remote*. According to estimates from 2017 to 2018, 1 in 5 Australians have multiple chronic conditions, and almost half (45.1%) of those with multimorbidity aged ≥18 years live in the lowest 2 socioeconomic areas, compared to 15.2% in the highest socioeconomic area [8]. Moreover, the prevalence of multimorbidity is greater among populations living in *inner and outer regional* areas than in *major cities* (21% and 18%, respectively). This pattern is not unique to Australia, with similar sociodemographic differences in multimorbidity reported in several other high-income countries [9-14]. Living with a chronic condition impacts an individual's quality of life and is accompanied with social and economic costs; this effect is amplified with multimorbidity [15,16]. Health inequity among disadvantaged populations may partially be explained by a degree of disadvantage pertaining to access to health and support services, as well as education and employment opportunities [17,18]. However, targeting lifestyle differences at a community level to reduce the vulnerabilities of disadvantaged populations [19] may provide positive benefits to overall health and narrow the inequalities in health.

Importantly, many chronic diseases share common lifestyle risk factors that are modifiable, such as poor diet, alcohol use, tobacco smoking, and vaping (electronic cigarette or "e-cigarette" use) [1,20-25]. Thus, reducing or avoiding the engagement in such behaviors can reduce total burden of disease figures. For example, in Australia, 38% of the total burden of disease in 2018 could have been prevented by reducing or avoiding the engagement in modifiable lifestyle behaviors [26]. However, engagement in these behaviors is not uniform across populations, with disparities existing between populations of different socioeconomic positions and between major cities and geographically remote areas. According to the *Australia's Children Report* [27], children and adolescents living in the lowest socioeconomic area compared to those living in the highest socioeconomic area had the following differences: children aged 5-14 years were less likely to meet recommended fruit guidelines (63% compared to 74%) and more likely to consume sugar-sweetened beverages (SSBs) at least once a week (53% compared to 33%); and adolescents aged 12-14 years were more likely to consume alcohol at risky levels (2.2% compared to 0.1%) and be current smokers (2.9% compared to 1.4%). Although not a nationally representative sample, similar sociodemographic differences in diet and alcohol and tobacco use were observed in a recent, large study of 6640 children aged 11-14 years across Australia [28]. Specifically, students of lower socioeconomic status were more likely to use alcohol and tobacco and have poorer diets than students of middle to upper socioeconomic status, and students from regional areas were more likely to use alcohol than students from major cities. Similar sociodemographic differences in diet and alcohol and tobacco use have been reported among adolescents overseas [29-32]. Although vaping has historically been relatively uncommon in Australia, its prevalence has increased over the past decade [33,34]. According to the 2019 National Drug Strategy Household Survey, there has been a significant increase in e-cigarette use among people aged ≥14 years (11.3% in 2019 compared to 8.8% in 2016), with 14.5% of adolescents aged 14-19 years reporting lifetime use of e-cigarettes [33]. Almost half (49.3%) of adolescents aged 14-19 years had never smoked a tobacco cigarette before e-cigarette use. Its use is becoming more common among youth in other countries [35-37], with recent US data from the National Youth Tobacco Survey of 27 million high and middle school students finding that 27.5% (4.1 million) of high school students and 10.5% (1.2 million) of middle school students reported recent use [38]. Moreover, data from the UK Household Longitudinal Study found that e-cigarette use was greater among socioeconomically disadvantaged youth, particularly among never-smokers [39], and the 2018-2019 Kansas Communities That Care Student Survey—a large, cross-sectional, school-based survey of middle and high school students in Kansas (N=132,803)—found that adolescents from rural areas were more likely to report current e-cigarette use than those living in urban areas [40]. A recent meta-analysis of 23 studies found that among people aged <20 years, e-cigarette use triples the risk of initiating tobacco smoking [41]. Although not all individuals who use e-cigarettes will progress to tobacco smoking, they are at risk of experiencing e-cigarette or vaping-associated lung injury [42,43]. Therefore, it is important to consider vaping during adolescence as a chronic disease risk factor.

To reduce the risk of chronic disease in adulthood and address the disproportionately higher rates of chronic disease burden experienced by disadvantaged populations, targeting these behaviors prior to their onset and entrenchment is crucial [44,45]. For a young person, adolescence tends to be a period marked by greater autonomy over their life, as well as increased risk-taking behavior [46-48]. It is a time period in which experimenting with and using alcohol, tobacco smoking, and vaping generally increase [47,49-51]. Moreover, eating habits typically include greater purchasing of fast food away from home [52], along with an increased intake of nutrient-poor food [53], such as discretionary food items (eg, hot chips) [54] and SSBs [55]. These behaviors typically co-occur [56-59] and have been referred to as "consumption behaviors" [60], reflecting that individuals actively consume food, alcohol, or tobacco. In the short-term, these behaviors are linked to detrimental impacts such as poorer quality of life [61], behavioral and mental health issues [62,63], and obesity [64,65]. Several of these behaviors may track into adulthood [66,67], heightening the individual's risk of chronic disease and associated burden over their lifetime, especially when they co-occur [20,68-70]. Altering this trajectory through the engagement of health promoting behaviors

during adolescence shows promise in improving both adolescent and adult health outcomes [71].

Using eHealth interventions (eg, computer-, web-, mobile-, or telephone-based) is an approach with evidence to support its efficacy in targeting multiple risk behaviors in adolescents [72]. Given that eHealth interventions are delivered via the internet, they confer the advantages of increased implementation fidelity, cost-effectiveness, and accessibility, as well as improved student engagement [73,74]. Previous systematic reviews of eHealth interventions targeting at least one of the 4 aforementioned behaviors among adolescents have found them effective in the following areas: improving dietary behavior (eg, eating less unhealthy foods, lowering consumption of total fat and saturated fat, and significantly increasing daily fruit and vegetable intake) [75]; reducing alcohol use [76,77]; and reducing the number of cigarettes and smoking frequency [78]. These reviews, however, focused on adolescents in the general population and did not include vaping as one of the targeted behaviors. It is unclear whether eHealth interventions adequately serve adolescents living in geographically remote or lower socioeconomic areas and are effective in preventing vaping among these populations.

The purpose of this review is to identify, evaluate, and synthesize evidence for the effectiveness of eHealth interventions targeting adolescents (aged 10-19 years) from disadvantaged backgrounds in preventing poor diet, alcohol use, tobacco smoking, and vaping. Considering the personal, social, and economic burden attributed to poor diet, alcohol use, tobacco smoking, and vaping, particularly among disadvantaged populations, this systematic review will contribute valuable insights to the knowledge base and ideally guide the future development of effective eHealth interventions. To our knowledge, this is the first systematic review to focus specifically on eHealth interventions targeting poor diet, alcohol use, tobacco smoking, and vaping among adolescents with lower socioeconomic backgrounds or living in geographically remote areas.

Methods

Guidelines and Registration

This protocol conforms to the PRISMA-P (Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols) guidelines [79] (see Multimedia Appendix 1) and was prospectively registered with PROSPERO (CRD42021294119).

Eligibility Criteria

The population, interventions, comparators, and outcomes approach was used to address the research question and eligibility criteria for this review [79].

Population

Eligible studies will be human research studies that target adolescents aged 10-19 years, which aligns with the World Health Organization's definition of "adolescent" [80]. Based on the demographic data presented by authors, studies will be eligible if the sample comprises any of the following: participants with lower socioeconomic status; participants living in rural, regional, or remote areas; and specific sub-group analysis among disadvantaged adolescents. Due to varying methods for measuring and defining socioeconomic status (eg, using the Family Affluence Scale III or Socio-Economic Indexes for Areas scores) and geographical remoteness (eg, based on relative access to services or termed as "countryside," "village," or "remote"), studies will not be limited to using the same measures or definitions; instead, socioeconomic status and geographical remoteness will be based on how they are conceptualized within the studies.

Intervention

Included studies will be those evaluating an eHealth intervention (eg, computer-, web-, mobile-, or telephone-based) targeting at least one consumption behavior—poor diet, alcohol, tobacco smoking, or vaping—among adolescents with lower socioeconomic status or living in geographically remote areas. Interventions addressing other risk behaviors in addition to poor diet, alcohol use, tobacco smoking, and vaping, such as poor sleep, sedentary screen time, and physical inactivity, will be eligible for inclusion as they may help to identify whether targeting a combination of certain behaviors influences outcomes.

Comparators

Eligible studies will compare the experimental group to a control group (eg, no intervention, education as usual, or an alternative intervention) or compare the changes in outcomes over time.

Outcomes

Primary outcomes of interest will include the reduced uptake or use of alcohol, tobacco, and vaping and improved or maintained dietary behaviors. Dietary behaviors will include any dietary outcomes, such as consumption of fruit and vegetables, SSBs, and nutrient-poor foods (junk food). Secondary outcomes of interest will include knowledge about diet, alcohol and tobacco use, alcohol-related harms, future intention to adopt health-related behaviors, motivators and barriers to adopting health-related behaviors, and other health behaviors such as sleep, sedentary screen time, and physical activity.

Studies

Included studies will be randomized controlled trials (including cluster randomized controlled trials) and quasi-experimental studies. They must be published in English and report original empirical findings. No date range restrictions apply for the included studies.

Search Strategy

A database search strategy was developed in consultation with a research librarian. Searches will be conducted in the Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials, PROSPERO, MEDLINE (Ovid), Embase (Ovid), Scopus, and PsycInfo (Ovid). The searching strategy to be used for all electronic databases is provided in Multimedia Appendices 2-8. Study references will be imported into EndNote software (Clarivate) and duplicates will be removed prior to being uploaded to Covidence software (Covidence) for screening. Grey literature websites and resources (eg, World Health Organization), conference abstracts, the reference lists

of eligible studies, book chapters, and unpublished works (eg, dissertations and theses) will also be searched to identify any additional studies.

Data Extraction and Screening

To balance rigor with the timeliness of the review, all study titles and abstracts will be screened by one reviewer (LE) against eligibility criteria, with a subset (25%) of studies double-screened by a second reviewer (NN, LAG, or KC). This method has been used in several systematic reviews [72,81,82]. Data will be extracted by one reviewer (LE) and reviewed by a second author (NN, LAG, or KC). Using the Template for Intervention Description and Replication [83], 2 authors (LE and NN, LAG, or KC) will independently pilot the standardized data extraction form by extracting 5 studies and then meet to discuss any required modifications to the form to ensure that all relevant data are captured, such as the following:

1. Publication details (study authors, year published) and study details (country, setting, sample size, and design)
2. Participant characteristics (age, gender, and sociodemographic information, including socioeconomic status and geographical remoteness)
3. Intervention characteristics (mode of delivery, duration and frequency of program, underpinning theory, material and components, and targeted risk behavior)
4. Comparison group characteristics
5. Primary and secondary outcomes
6. Measurement tools

The corresponding authors of the published articles will be contacted if additional information that was not reported is required.

Risk of Bias

The risk of bias of the included studies will initially be judged by one independent reviewer (LE) using the Cochrane Revised Risk of Bias Tool [84]. Sources of bias covered in this tool include the following: randomized allocation to groups, allocation concealment, blinding of participants and personnel, blinding outcome, handling of incomplete data, selective reporting, and other biases not covered. A second reviewer (NN, LAG, or KC) will also rate the risk of bias of the included studies, with any inconsistencies resolved through consultation.

Analysis

A narrative analysis will be adopted to synthesize the study findings from the included studies. To begin, one reviewer (LE) will tabulate the following results to compare study components and findings: sample characteristics (eg, location, socioeconomic status, gender, and age); risk behavior targeted; intervention content and components (including duration and delivery method); underpinning theory; and primary and secondary outcome effect sizes. The quality of the body of evidence will be independently rated by 2 reviewers (LE and NN, LAG, or KC) using the Grading of Recommendations Assessment, Development and Evaluation framework [85]. LE will then follow the UK Economic and Social Research Council guidance for narrative synthesis in systematic reviews [86], identify themes and factors, and subsequently, summarize the studies in a narrative synthesis.

Results

As of December 2021, title and abstract screening of 3216 articles was completed, and full-text review was underway. The results will be summarized in a narrative synthesis. The systematic review is expected to be completed and submitted for publication in 2022.

Discussion

Disadvantaged adolescents, such as those with lower socioeconomic status or living in geographically remote areas, may be more vulnerable to experiencing greater chronic disease burden than their counterparts, as evidenced by the disproportionate levels of chronic disease burden among disadvantaged adult populations [1-6]. Consumption-related chronic disease risk behaviors, such as poor diet, alcohol use, tobacco smoking, and vaping, tend to be greater among these populations than their counterparts [27-32,39,40]. In order to reduce this burden, prevention and early intervention is critical. Several systematic reviews have supported the efficacy of universal eHealth interventions in targeting diet and alcohol and tobacco use among adolescents [75-78]; however, it is unclear whether eHealth interventions adequately serve adolescents living in geographically remote or lower socioeconomic areas. In light of this, this review is the first to systematically examine and synthesize evidence on eHealth interventions targeting disadvantaged adolescents (aged 10-19 years) from socioeconomically disadvantaged backgrounds in preventing poor diet, alcohol use, tobacco smoking, and vaping. We expect that literature on eHealth interventions focused on preventing vaping among disadvantaged adolescents may be limited given that its use has only become more common over the past decade, unlike the other behaviors covered in this review. The results from this systematic review will provide valuable knowledge on the important intervention components of effective eHealth interventions and guide the development of tailored eHealth interventions that are better able to prevent and reduce health risk behaviors among these populations. Ultimately, addressing these health risk behaviors to reduce the vulnerabilities of disadvantaged populations [19] has the potential to provide positive benefits to overall health and narrow the inequalities in health. The results from this review will be disseminated through peer-reviewed journals and conferences to help guide future research projects in this area.

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Authors' Contributions

All authors (LE, NN, LAG, and KC) conceived the initial idea for the systematic review. LE drafted the manuscript, and NN, LAG, and KC provided critical insights. All authors contributed to the revision of the manuscript and approved the final version.

Conflicts of Interest

None declared.

Multimedia Appendix 1

PRISMA-P (Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols) checklist.
[PDF File (Adobe PDF File), 183 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Cochrane Database of Systematic Reviews (CDSR) search strategy.
[PDF File (Adobe PDF File), 62 KB-Multimedia Appendix 2]

Multimedia Appendix 3

Cochrane Central Register of Controlled Trials (CENTRAL) search strategy.
[PDF File (Adobe PDF File), 62 KB-Multimedia Appendix 3]

Multimedia Appendix 4

PROSPERO search strategy.
[PDF File (Adobe PDF File), 8 KB-Multimedia Appendix 4]

Multimedia Appendix 5

MEDLINE (Ovid) search strategy.
[PDF File (Adobe PDF File), 14 KB-Multimedia Appendix 5]

Multimedia Appendix 6

Embase (Ovid) search strategy.
[PDF File (Adobe PDF File), 14 KB-Multimedia Appendix 6]

Multimedia Appendix 7

Scopus search strategy.
[PDF File (Adobe PDF File), 10 KB-Multimedia Appendix 7]

Multimedia Appendix 8

Psycinfo (Ovid) search strategy.
[PDF File (Adobe PDF File), 14 KB-Multimedia Appendix 8]

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Abbreviations

PRISMA-P: Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols
SSB: sugar-sweetened beverage

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Appendix C

Moderating effects of socioeconomic status and geographical location on the Health4Life school-based intervention

Appendix C

Preface

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LE led the development of this paper using data from the Health4Life trial. The authors are LE, LAG, NCN, SO and KEC. All authors were involved in conceptualisation. KEC and NCN secured funding for the Health4Life trial. KEC and LAG were responsible for ethics and governance and overall trial administration with oversight from NCN. KEC, NCN, and LAG provided supervision. LE developed the methodology and conducted formal analysis and data visualisation with support from SO. LE wrote the original manuscript. All authors were involved in the review, read and approved the final version and agreed to publication.

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Moderating effects of socioeconomic status and geographical location on the Health4Life school-based intervention

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ABSTRACT

Objective: This study evaluated the moderating effects of socioeconomic status (SES) and geographical location on the efficacy of an eHealth school-based multiple health behaviour change intervention – *Health4Life* – in targeting alcohol and tobacco use, dietary intake, knowledge, behavioural intentions, and psychological distress over 24-months.

Methods: Data from the *Health4Life* cluster-randomised controlled trial conducted from 2019 to 2021 in 71 Australian secondary schools were analysed (N=6639; baseline age 11-14yrs). Schools were from metropolitan (89%) and regional (11%) areas, and participants' SES was classified as low (15%), mid (37%), and high (48%) relative to the study population. Primary outcomes included alcohol and tobacco use, and a composite indicator of poor diet. Secondary outcomes were knowledge, behavioural intentions, and psychological distress. Latent growth models assessed moderating effects of SES and geographical location on between-group change over 24-months.

Results: Geographical location moderated the intervention's effect on odds of reporting a poor diet (OR = 1.79, 95% CI = 1.32–2.43, $p < 0.001$) and diet-related behavioural intentions (OR = 0.71, 95% CI = 0.56–0.89, $p = 0.024$) over time. Subset analyses indicated that intervention participants in regional areas had higher odds of reporting a poor diet (OR = 1.61, 95% CI = 1.13–2.29, $p = 0.008$), while those in metropolitan areas had higher odds of improving diet-related behavioural intentions (OR = 1.13, 95% CI = 1.01–1.27, $p = 0.041$), compared to the control group. No other significant moderation effects were observed.

Conclusions: While significant disparities were generally not observed, the geographical differences in intervention effects on diet and diet-related intentions suggest that co-designed and tailored approaches may benefit disadvantaged adolescents to address the disproportionately high rates of lifestyle risk behaviours among these priority populations.

1. Introduction

Sociodemographic inequalities, including socioeconomic status (SES) and geographical location (e.g., urban versus rural areas), significantly contribute to chronic disease burden and are critical determinants of access to resources and health outcomes in society (Australian Institute of Health and Welfare, 2023; Robards et al., 2018). Adolescents from low SES and geographically remote contexts are particularly susceptible to this burden (Australian Institute of Health and Welfare, 2021). The 2018 Australian Burden of Disease Study (Australian Institute of Health and Welfare, 2021), reports a progressive increase in disability-adjusted life years from affluent to disadvantaged socioeconomic areas, and from major cities to remote areas, with 1.6 and 1.4 times higher rates, respectively. Despite unique differences between adolescents of low SES and geographically remote backgrounds, both groups face similar challenges in achieving health equity. Therefore, the term "disadvantaged" is used to describe these individuals in this context. Disadvantaged adolescent populations encounter various obstacles that impede their access to health, including stigmatisation, lack of social support, limited access to affordable services, and education opportunities (Australian Institute of Health and Welfare, 2023; Robards et al., 2018).

Disadvantaged adolescent populations, both in Australia and globally, exhibit higher rates of modifiable lifestyle risk behaviours such as poor diet, alcohol use, and tobacco smoking (Australian Institute of Health and Welfare, 2020; Warren et al., 2017; Wiggins et al., 2020).

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These may continue into adulthood, increasing the risk of chronic disease and associated burden, especially when they occur together (Krokstad et al., 2017). Adolescence is a critical developmental period (Sawyer et al., 2012), characterised by increased risk-taking tendencies, including experimentation with alcohol and smoking (Degenhardt et al., 2016), and consuming unhealthy foods (Australian Institute of Health and Welfare, 2018). Clustering or the co-occurrence of these behaviours in adolescence is common (Uddin et al., 2020), and linked with adverse outcomes, including obesity (Bardach et al., 2023), reduced quality of life (Hoare et al., 2019) and mental ill-health (Champion et al., 2018; Gardner et al., 2022a). Indeed, research has reported that adolescents with a history of early-life low SES often face co-occurring adverse health and educational challenges (Villadsen et al., 2023). Therefore, prioritising prevention during adolescence is crucial for promoting healthy behaviours, mitigating the risk of chronic diseases in adulthood, and addressing health disparities experienced by this vulnerable population.

Electronic health (eHealth) interventions hold promise in benefiting disadvantaged adolescents by providing accessible and low-cost resources that can increase student engagement and implementation fidelity (Champion et al., 2019). Multiple systematic reviews have demonstrated the efficacy of universal eHealth interventions in preventing and addressing poor diet (Kemp et al., 2021), tobacco smoking (Taylor et al., 2017), and/or reducing alcohol use (Kazemi et al., 2021) among adolescents. Although, a recent meta-analysis of universal school-based prevention eHealth interventions targeting multiple health risk behaviours found them ineffective in preventing alcohol consumption or smoking and reducing fat, sugar-sweetened beverages (SSB), or snack consumption (Champion et al., 2019). The review recommended focusing on skill development and social influence and competence theories for improved outcomes. Despite these mixed findings, evidence supports the effectiveness of universal eHealth interventions in preventing or delaying the onset of modifiable health risk behaviours (Newton et al., 2017; Qiu et al., 2022). However, their effectiveness for disadvantaged adolescents is not as well-known, with only one systematic review published on eHealth prevention interventions targeting poor diet, alcohol use, and tobacco smoking among disadvantaged adolescents (Egan et al., 2023). The review indicated that eHealth interventions can be effective in targeting poor diet (e.g., decreasing SSB consumption) and alcohol use (e.g., reducing binge drinking at 1-month follow-up among intervention completers) among disadvantaged adolescents. However, it also acknowledged limitations due to the scarcity of published studies on this topic, with only 15 publications assessing 14 interventions eligible for inclusion.

The Australian *Health4Life* initiative is an innovative eHealth school-based intervention targeting multiple lifestyle risk behaviours among adolescents: alcohol use, tobacco smoking, poor diet, physical inactivity, poor sleep, and sedentary recreational screen time (Teesson et al., 2020). Co-designed with young people, *Health4Life* incorporates personalised feedback and is grounded in social influence, social cognitive, and self-determination theories (Champion et al., 2020). Results from a cluster randomised controlled trial (RCT) of *Health4Life* found significant effects on reducing behavioural intentions to try alcohol and tobacco at post-intervention (O'Dean et al., Under review), improving mental health outcomes (Smout et al., 2024) and knowledge about chronic disease risk factors over 24-months (Champion et al., 2023). However, the RCT reported no significant intervention effects on modifying alcohol or tobacco use, poor diet, physical inactivity, poor sleep or screen time across the entire sample (Champion et al., 2023). Despite *Health4Life*'s positive reception by students (74.8%) and teachers (84%), and the significant improvement in knowledge, this did not translate into behaviour change. *Health4Life* baseline data (n = 6639 11–14 year-olds across NSW, WA, and QLD) revealed sociodemographic disparities in diet, alcohol, and tobacco use (Champion et al., 2021). For instance, students from regional areas were more likely to use alcohol than those from major cities, and students with lower SES were more likely to use alcohol and tobacco and have poorer diets than their peers with middle to upper SES. Given these disparities we expect that *Health4Life*'s efficacy may differ in these subgroups, potentially due to distinct challenges influencing their health behaviours differently. Tailored approaches may be needed, however, evidence is currently unclear.

Nonetheless, considering the significant influence of SES and geographical factors on health-related behaviours, it is essential to examine their impact on the efficacy of interventions such as *Health4Life*. This study aims to evaluate the moderating effects of SES and geographical location on the efficacy of the *Health4Life* intervention in reducing alcohol and tobacco use, improving dietary intake, knowledge of chronic disease risk behaviours, behavioural intentions, and reducing psychological distress.

2. Methods

2.1. Participants and procedure

The current study uses baseline to 24-month follow-up data from the *Health4Life* study (Teesson et al., 2020), a cluster RCT in 71 secondary schools across Australia. Recruitment details have been reported previously (Champion et al., 2023). Briefly, 71 schools were block randomised (1:1) by a biostatistician independent to recruitment to either the *Health4Life* intervention (N=36) or active control group (usual health education; N=35). Randomisation was stratified by school location (state/region) and gender composition (coeducational, mostly female [>60 %], or mostly male [>60 %]). It was not possible to blind students, teachers, and researchers to group assignment, as is standard with school-based interventions.

The study's parental consent approaches varied based on the ethical requirements of the schools involved. While 40 schools provided an opt-out option, 31 required active written and oral consent (i.e., opt-in). All students provided active written consent to participate in the study.

The intervention group received *Health4Life*, consisting of six web-based modules delivered during health education lessons, ideally once per week. Based on social influence, social cognitive, and self-determination theories to prevent multiple lifestyle risk behaviours, key behaviour change techniques are integrated into 20-minute interactive cartoon storylines with characters similar in age to grade 7 students (Champion et al., 2020). These cartoons, the core component of *Health4Life*, impart evidence-based information about health and social consequences of poor diet, alcohol use, tobacco smoking, physical inactivity, poor sleep, and sedentary recreational screen time, while also promoting resistance skills, normative education, and autonomous motivation. Students complete short online quizzes after each module, and factsheets for teachers and students are available to reinforce the content. *Health4Life* is supplemented by web-based tailored feedback on adherence to national health guidelines, optional online or teacher-led activities, and a smartphone app designed to encourage self-monitoring of behaviours and goal setting. Control schools delivered usual health education, approximately once a week.

Participants completed self-report online surveys during class at four time points: baseline (2019); immediately following the intervention (2019); 12-months after baseline (2020); 24-months after baseline (2021). To maximise retention, two participants from each school were randomly allocated a AUD$100 gift voucher for completing the surveys.

This trial was prospectively registered with the Australian New Zealand Clinical Trials Registry (ACTRN12619000431123) and adheres to CONSORT guidelines.

2.2. Measures

2.2.1. Sociodemographic factors

Students provided self-reported information on gender, age, SES and geographical location. SES was categorised into lower, middle and upper

groups based on Family Affluence III ridit scores (Elgar et al., 2017), and geographical location was classified as metropolitan or regional based on the Australian Statistical Geography Standard Remoteness Structure (Australian Bureau of Statistics, 2021).

2.2.2. Primary outcomes

Diet: The Student Physical Activity and Nutrition Survey (SPANS) measured the consumption of SSBs, fruit, vegetables, and discretionary foods (Hardy et al., 2016). A composite indicator of poor diet was then calculated. Individuals were classified as having a poor diet if they reported high SSB consumption (5–6 cups/week or 1 or more cups/day of SSB) or met two or more of the following conditions: consuming fewer than two servings of fruit per day, consuming fewer than five servings of vegetables per day, or consuming more than one serving of discretionary food items per day. The cut-offs for fruit and vegetable intake were based on the Australian Dietary Guidelines (National Health and Medical Research Council, 2013), while nutritionists and health recommendations guided SSB and discretionary food variables.

Alcohol: A single item measured participants' consumption of a full standard drink by asking participants, "Have you had a full standard alcoholic drink in the past 6 months?" (0 = No, 1 = Yes). To facilitate participants' responses, they were shown a pictorial chart displaying the standard drink quantities of various types of alcoholic beverages and sizes.

Tobacco: A single item measure from the Youth Risk Behaviour Survey assessed tobacco use with participants asked, "In the past 6 months, have you tried cigarette smoking, even one or two puffs?" (0 = No, 1 = Yes) (Brener et al., 2013).

2.2.3. Secondary outcomes

Knowledge: A 20-item scale assessed participants' knowledge of *Health4Life* study content, including awareness of chronic disease risk factors, alcohol guidelines, prevalence of alcohol and tobacco use among young Australians, and the impact of six lifestyle risk behaviours on physical and mental health. Items were presented as "True", "False", "Don't Know" statements, and scores were totalled to produce an overall knowledge score.

Behavioural Intentions: Participants self-reported their intentions to participate in or modify behaviours relating to poor diet, alcohol and tobacco use. Alcohol intentions were evaluated using established measures (Newton et al., 2012), with items for tobacco and poor diet (specifically SSBs including energy drinks, soft drinks, sports drinks, or cordial) adapted from these measures. Participants rated their likelihood of trying alcohol and tobacco on a scale from 0 (very unlikely) to 4 (very likely). For SSBs, they indicated their intention to replace them with water on a scale from 0 (not at all true of me) to 3 (very true of me) on all or most days over the next three months. Responses were then converted into binary variables for subsequent analyses in this study. Scores of 0–2 for alcohol and tobacco questions indicated no intention to engage in alcohol use or tobacco smoking, while scores of 3–4 indicated an intention to do so. Regarding SSBs, responses of 0–1 were recoded as no intention to replace SSB consumption with water, while responses of 2–3 indicated an intention to make the substitution.

Psychological Distress: The Kessler 6 (K6) scale, a widely used and validated measure, assessed psychological distress among adolescents by evaluating six symptoms experienced by individuals over the past four weeks (Furukawa et al., 2003; Mewton et al., 2016). These symptoms include feeling nervous, hopeless, or restless. Participants rated each symptom on a 5-point Likert scale ranging from "none of the time" to "all of the time". Scores were totalled to create a composite score, with higher scores indicating greater psychological distress.

2.3. Statistical analysis

A post-hoc exploratory moderation analysis was chosen for the current study. Latent growth curve models (LGMs) in Mplus (v 8.4. (Muthén & Muthén, 2017)) were used to evaluate the moderating effects of SES and geographical location on primary and secondary outcomes over 24-month post baseline assessments. Various LGMs were used based on the distribution of the outcome variables, including binary, continuous, or ordinal models. To determine the optimal time structure and interpretation of slope estimates for each outcome, we explored various specifications of time scores, including linear, quadratic, and freely estimated, on unconditional LGMs. We compared model fit using Akaike information criterion (AIC), Bayesian information criterion (BIC), and sample-size adjusted BIC. Further details regarding model interpretation is provided in the appendices on page 8. The analysis applied the full-information maximum likelihood (FIML) estimation within the LGMs, aligning with intention-to-treat principles to handle missing data. FIML uses all available information when estimating parameters, and it is recognised for its superiority over conventional methods within the context of LGMs (Schafer & Graham, 2002). To account for the effect of testing multiple outcomes, the Benjamini-Hochberg approach, also known as the false discovery rate control, was applied (Benjamini & Hochberg, 1995). Unlike more conservative methods such as the Bonferroni correction, the Benjamini-Hochberg approach offers increased power to identify true associations when testing multiple outcomes. To interpret statistically significant interactions ($p < 0.05$), we conducted subset analyses that investigated the main effects of intervention within each level of the moderating variables (i.e., SES or geographical location).

2.4. Ethics

The *Health4Life* study was approved by the University of Sydney (2018/882), the University of Queensland (2019000037), Curtin University (HRE2019–0083), and ethics committees in the relevant school sectors.

3. Results

3.1. Descriptive statistics

A total of 6,639 students from 71 schools participated in the baseline survey, constituting the analysed sample for this study. The students had a mean age of 12.7 years (SD 0.50; range 11–14 years). In terms of gender, 49.9% (n = 3,311) identified as male, 48.3% (n = 3,204) identified as female, 0.5% (n = 30) identified as non-binary or gender fluid, 0.1% (n = 9) had a different gender identity, and 1.0% (n = 69) preferred not to disclose their gender identity. The sample included students from diverse socioeconomic backgrounds, with 15% classified as low SES, 37% as mid SES, and 48% as high SES. Furthermore, the sample represented both metropolitan and regional areas, with 89% residing in metropolitan areas and 11% in regional areas (Table 1). Retention rates and the number of students who completed follow-up surveys are reported in Appendix Fig. 1.

3.2. Moderation effects in latent growth curve models

3.2.1. Conditional growth curve models

There was a significant moderating effect of geographical location on intervention effectiveness for poor diet (OR = 1.79, 95% CI = 1.32–2.43, $p < 0.001$) (Fig. 1). Subset analyses revealed for those who resided regionally, there was greater growth in the odds of having a poor diet in the intervention group compared to the control (OR = 1.61, 95% CI = 1.13–2.29, $p = 0.008$), and little evidence of a difference between groups for those residing in metropolitan cities (OR = 0.99, 95% CI = 0.86–1.14, $p = 0.915$) (Appendix Table 4). There was little evidence supporting a moderation effect of SES on intervention effectiveness for poor diet (OR = 0.99, 95% CI = 0.87–1.13, $p = 0.856$) (Table 3). In addition, geographical location significantly moderated the intervention effectiveness in promoting behavioural intentions to swap SSB for water

Table 1
Baseline (2019) sample characteristics of adolescents participating in the Australian Health4Life Study.

Characteristic	Socioeconomic status n (%)						Geographical location n (%)				
	Low SES: Control 351 (5.3)	Low SES: Health4Life 558 (8.4)	Mid SES: Control 1005 (15.1)	Mid SES: Health4Life 1204 (18.1)	High SES: Control 1336 (20.1)	High SES: Health4Life 1560 (23.5)	Metropolitan: Control 2650 (39.9)	Metropolitan: Health4Life 3303 (49.8)	Regional: Control 380 (5.7)	Regional: Health4Life 306 (4.6)	**Total**
Age (mean, SD)	12.66 (0.49)	12.65 (0.51)	12.63 (0.51)	12.67 (0.49)	12.64 (0.51)	12.66 (0.49)	12.64 (0.51)	12.65 (0.50)	12.64 (0.49)	12.79 (0.49)	12.7 years (0.50)
Gender n (%)											
Male	178 (50.9)	330 (59.1)	470 (47.0)	659 (54.7)	612 (45.8)	702 (45.0)	1239 (46.9)	1671 (50.7)	207 (54.6)	194 (63.6)	3,311 (49.9)
Female	164 (46.9)	217 (38.9)	510 (50.9)	520 (43.2)	705 (52.8)	844 (54.1)	1354 (51.2)	1574 (47.8)	167 (44.1)	108 (35.4)	3,204 (48.3)
Non-binary or gender fluid	3 (0.9)	5 (0.9)	8 (0.8)	4 (0.3)	3 (0.2)	4 (0.3)	15 (0.6)	14 (0.4)	1 (0.3)	0 (0.0)	30 (0.5)
Different gender identity	0 (0.0)	1 (0.2)	1 (0.1)	3 (0.2)	2 (0.1)	1 (0.1)	4 (0.2)	4 (0.1)	0 (0.0)	1 (0.3)	9 (0.1)
Preferred not to disclose	5 (1.4)	5 (0.9)	12 (1.2)	18 (1.5)	14 (1.0)	9 (0.6)	30 (1.1)	33 (1.0)	4 (1.1)	2 (0.7)	69 (1.0)
State n (% of participants)											
New South Wales	220 (62.7)	355 (63.6)	487 (48.5)	645 (53.6)	639 (47.8)	929 (59.6)	1392 (52.5)	1808 (54.7)	103 (27.1)	233 (76.1)	37 schools (53.2)
Queensland	56 (16.0)	141 (25.3)	214 (21.3)	412 (34.2)	332 (24.9)	493 (31.6)	655 (24.7)	1133 (34.3)	0 (0.0)	0 (0.0)	18 schools (26.9)
Western Australia	75 (21.4)	62 (11.1)	304 (30.2)	147 (12.2)	365 (27.3)	138 (8.8)	603 (22.8)	362 (11.0)	277 (72.9)	73 (23.9)	16 schools (19.8)

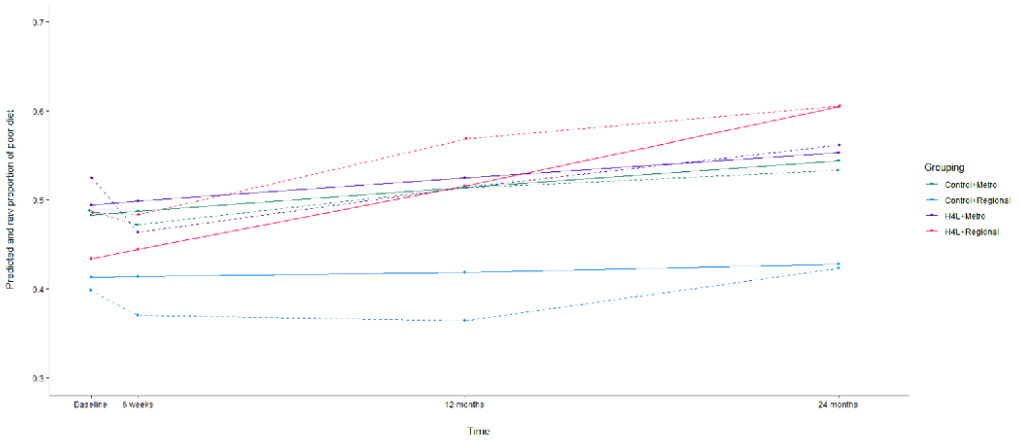

Fig. 1. Predicted and raw proportion of poor diet among metropolitan and regional participants in the Australian Health4Life Study. Solid lines are raw values and dotted lines are predicted values.

(OR = 0.71, 95% CI = 0.56–0.89, p = 0.024 (Fig. 2)). Subset analyses revealed for those who resided in metropolitan cities, there was a significantly greater increase in the odds of intending to swap SSB for water in the intervention group compared to the control (OR = 1.13, 95% CI = 1.01–1.27, p = 0.041), and little evidence of a difference between groups for those who resided regionally (OR = 0.97, 95% CI = 0.72–1.32, p = 0.857). There was little evidence of a moderation effect of SES on the intervention effectiveness in targeting diet-related behavioural intentions at 24-months (OR = 1.03, 95% CI = 0.92–1.15, p = 0.685).

There was little evidence for a moderation effect of SES or geographical location on the average change in odds of alcohol (OR = 0.81, 95% CI = 0.52–1.25, p = 0.489) or tobacco use (OR = 0.60, 95% CI = 0.37–0.95, p = 0.124) in the past 6-months, and alcohol-related (OR = 0.98, 95% CI = 0.81–1.19, p = 0.856) and tobacco-related behavioural intentions (OR = 0.86, 95% CI = 0.68–1.08, p = 0.457) over the 24-months. Likewise, over the 24-month duration there were no moderation effects of SES on the mean knowledge scores of chronic disease risk factors (0.08, SE=0.09, p = 0.502) or psychological distress (−0.13, SE=0.13, p = 0.489), nor of geographical location on the mean knowledge scores of chronic disease risk factors (−0.42, SE=0.26, p – 0.365) or psychological distress (0.33, SE=0.36, p = 0.495) (Tables 2 & 3).

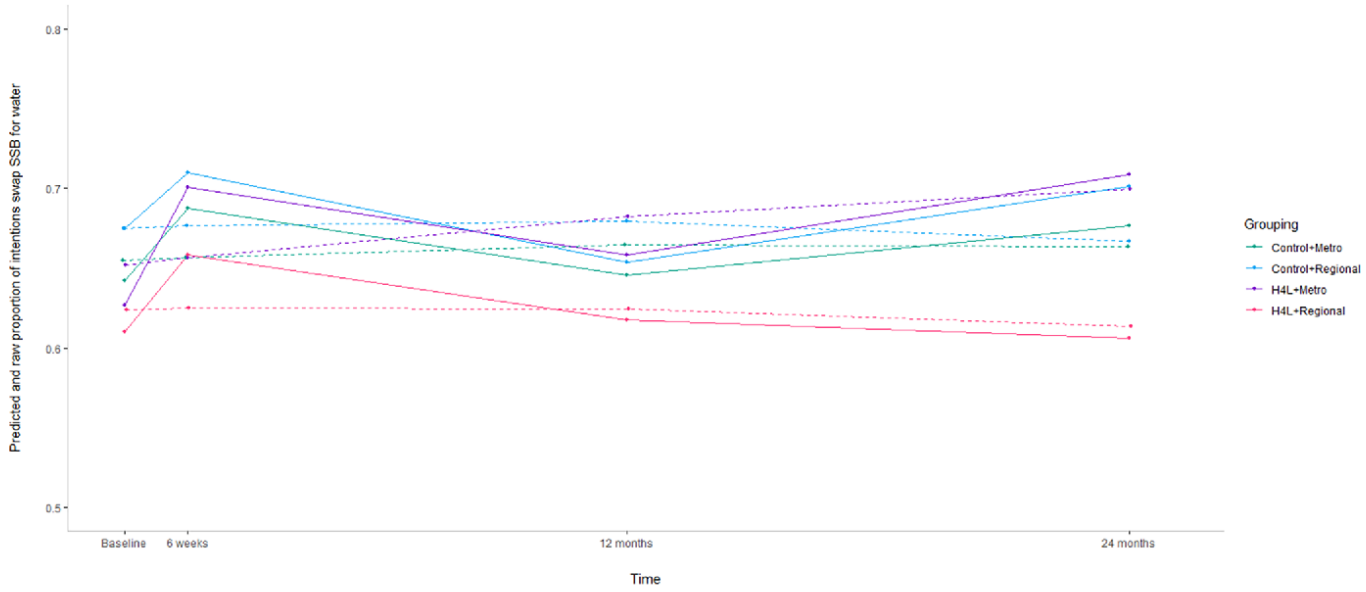

Fig. 2. Predicted and raw proportion of intentions to swap SSB for water among metropolitan and regional participants in the Australian Health4Life Study. Solid lines are raw values and dotted lines are predicted values.

Table 2
Summary of logistic latent growth parameters, CIs and SE investigating the effects of SES on moderating the odds of study outcomes from the Australian Health4Life Study.

	Intercept		Slope	
Logistic latent growth model				
	OR (CI)	p	OR (CI)	p
Poor diet	1.13 (0.88, 1.47)	0.336	0.99 (0.87, 1.13)	0.856
Alcohol	0.86 (0.52, 1.42)	0.554	0.81 (0.52, 1.25)	0.489
Tobacco	0.78 (0.43, 1.44)	0.440	0.60 (0.37, 0.95)	0.124
Diet intentions	0.97 (0.81, 1.16)	0.743	1.03 (0.92, 1.15)	0.685
Alcohol intentions	0.62 (0.39, 0.99)	0.046	0.98 (0.81, 1.19)	0.856
Tobacco intentions	0.88 (0.57, 1.38)	0.587	0.86 (0.68, 1.08)	0.457
Continuous latent growth model				
	b(SE)	p	b(SE)	p
Knowledge	−0.43(0.19)	0.022	0.08(0.09)	0.502
Psychological Distress	−0.11(0.25)	0.671	−0.13(0.13)	0.489

Table 3
Summary of logistic latent growth parameters, CIs and SE investigating the effects of Metropolitan-Regional on moderating the odds of study outcomes from the Australian Health4Life Study.

	Intercept		Slope	
Logistic latent growth model				
	OR (CI)	p	OR (CI)	p
Poor diet	1.13 (0.87, 1.46)	0.369	1.79 (1.32, 2.43)	<0.001
Alcohol	0.84 (0.51, 1.39)	0.501	2.53 (0.44, 14.48)	0.489
Tobacco	0.80 (0.43, 1.48)	0.473	5.92 (1.45, 24.18)	0.069
Diet intentions	0.96 (1.15, 1.27)	0.666	0.71 (0.56, 0.89)	0.024
Alcohol intentions	0.60 (0.38, 0.97)	0.037	0.76 (0.44, 1.33)	0.489
Tobacco intentions	0.83 (0.55, 1.27)	0.392	2.01 (0.75, 5.38)	0.437
Continuous latent growth model				
	b(SE)	p	b(SE)	p
Knowledge	−0.38(0.19)	0.046	−0.42(0.26)	0.365
Psychological Distress	−0.10(0.25)	0.679	0.33(0.36)	0.495

4. Discussion

This is the first study to examine the moderating effects of SES and geographical location on the effectiveness of the *Health4Life* intervention in reducing alcohol and tobacco use, improving dietary intake, knowledge of chronic disease risk behaviours and behavioural intentions, and reducing psychological distress over 24-months. Overall, the study found little evidence for a moderation effect, with the exception of diet-related outcomes by geographical location. This is consistent with the primary outcomes of the *Health4Life* RCT, which revealed no significant intervention effects on alcohol use, tobacco smoking and poor diet across the entire sample (Champion et al., 2023).

Importantly, *Health4Life* draws from social influence, social cognitive, and self-determination theories (Champion et al., 2020), which aligns with recommendations for eHealth interventions among adolescents of low SES or of geographically remote backgrounds (Egan et al., 2023). However, *Health4Life* was not specifically designed to address the unique experiences of disadvantaged adolescents, who often encounter structural barriers including limited access to resources, support, and economic constraints (Australian Institute of Health and Welfare, 2023; Robards et al., 2018). These barriers create a more challenging environment for adopting and maintaining positive health behaviours compared to their more advantaged peers. For instance, healthy food options are less affordable and less available in low SES and regional areas (Love et al., 2018), and there may be lower levels of social support (Gautam et al., 2023), both of which are crucial for sustaining healthy behaviours. Moreover, *Health4Life*'s foundational principles assume a level of autonomy and resource availability that disadvantaged adolescents may not have e.g. financial constraints limiting control over health choices. While the theoretical underpinnings of *Health4Life* are sound, their practical application may be undermined if positive health behaviours are not modelled or encouraged (Bandura, 2004) which may be the reality in disadvantaged adolescents' environments. Together this may explain why *Health4Life* was limited in effectively modifying alcohol and tobacco use, knowledge, alcohol- and tobacco-related behavioural intentions, and psychological distress in this population.

The present findings suggest that, generally, outcomes were not influenced by SES and geographical location. Instead, the intervention's effects may be attributed to other underlying mechanisms. For instance,

despite the myriad of challenges linked to varying SES and regional contexts, *Health4Life* maintained a positive impact on adolescents' knowledge of chronic disease risk behaviours, potentially due to other factors such as personal motivation or learning styles. The absence of significant moderation effects on other outcomes, including alcohol and tobacco use, suggests that *Health4Life*'s impact on these behaviours may vary depending on individual characteristics and contextual factors, such as family dynamics and social support that could be targeted through tailored interventions. For example, interventions may target the home environment by involving parents. Additionally, including peers in the intervention process may help create a supportive network. These refinements may benefit *Health4Life*'s efficacy for all participants, and to further enhance *Health4Life*'s efficacy for low SES and regional populations, addressing structural barriers and other social determinants that could influence health behaviours is essential. Given disadvantaged adolescents exhibit higher rates of these lifestyle risk behaviours than their more advantaged peers (Australian Institute of Health and Welfare, 2020; Warren et al., 2017; Wiggins et al., 2020), this tailoring may lead to more significant and equitable health improvements among these populations. This highlights the importance of co-design and tailoring interventions to disadvantaged populations (Egan et al., 2023). Emerging interventions such as Just-in-Time-Adaptation, which use real-time data to provide personalised support through digital platforms, may also be beneficial for this population as they are easily accessible, individually tailored and practical (Partridge & Redfern, 2018).

Diet-related outcomes are an exception to the null findings. *Health4Life* improved diet-related behavioural intentions for those residing in metropolitan areas, but not regional areas. However, this did not translate into dietary behaviour change, contrasting with a separate study that improved both behavioural intentions and fruit and vegetable consumption (Kothe et al., 2012). This discrepancy challenges the Theory of Planned Behaviour, which posits that intention is a proximal determinant of behaviour (Bosnjak et al., 2020). External factors, such as peer pressure influencing dietary choices (Ragelienė & Grønhøj, 2020), coupled with socio-cultural influences (e.g., prevalent advertising of unhealthy foods in metropolitan areas (Richmond et al., 2020; Sainsbury et al., 2017)) may have counteracted the positive intentions fostered by the intervention, making it more challenging for these adolescents to adopt healthier eating habits. Future interventions should focus on modifying behavioural intentions and strategies to mitigate these external influences.

Unexpectedly, regional participants in the intervention group had greater growth in the odds of having a poor diet compared to controls. This disparity may be due to the health education provided in regional control groups placing a stronger emphasis on dietary education than *Health4Life*. While *Health4Life*, given its multiple behaviour change framework, provided an equivalent of one to two 15-minute lessons on diet, teacher-reported data revealed that most regional control schools dedicated a minimum of one to two 40-minute lessons solely to diet education, and some delivered up to six lessons. Within the Australian curriculum, students learn about making healthy and safe food choices, including food-serving recommendations from *The Australian Guide to Healthy Eating* and practical advice on choosing healthy options from the school canteen (ACARA Version 9.0). The control schools' focused approach, coupled with greater frequency and depth on diet education than *Health4Life*, may have equipped students with more knowledge and strategies for making healthier food choices. This suggests *Health4Life* should incorporate a more intensive dietary education component, especially in regional areas. Although it is worth noting that data were not collected on other characteristics in the control and *Health4Life* schools, such as policies (canteen, nutrition, other health promotion policies) and food environments, which may have affected diet outcomes. Nevertheless, as previously mentioned, *Health4Life* was not specifically designed for disadvantaged adolescents, and regional areas may have unique challenges that the intervention did not adequately address. For instance, control schools may have better addressed the social and environmental context, including lower affordability or availability of healthy food, to ensure health-promoting messages were relevant, practical, and accessible within the local context. To overcome this, future studies could adopt matched sampling methods to ensure the control and intervention schools do not drastically differ in the amount of health education they deliver (Chondros et al., 2021; Hemming & Taljaard, 2023). A process evaluation of *Health4Life* in regional schools is also needed to understand the implementation context and identify any other factors that may have contributed to this unintended effect. Ultimately, the conflicting diet-related findings observed in this study highlight the need for further research to replicate and explore potential explanations, informing improvements in future interventions targeting dietary behaviours among disadvantaged adolescents.

4.1. Strengths and limitations

This study has several strengths and limitations. Firstly, the use of the composite diet risk score provides an overall perspective on diet, however, may overlook specific dietary nuances. Although the fruit and vegetable variables align with official government guidelines (National Health and Medical Research Council, 2013), the lack of guidelines for SSB and junk food variables required input from a multidisciplinary team, including nutritionists, and following health recommendations to determine the "at-risk" cutoffs for these variables. Additionally, the item assessing diet-related intentions focused solely on intentions to swap SSB for water. Although SSB is one relevant indicator of poor diet (National Health and Medical Research Council, 2013), future studies should adopt more comprehensive measures.

The use of the Family Affluence Scale III as a proxy measure for SES, while practical, simplifies evaluation by relying on a limited number of indicators, such as overseas holidays (Torsheim et al., 2016). This approach may overlook the multidimensional aspects of SES, including income and education. Furthermore, self-reported information introduces potential bias, as respondents may interpret scale items differently. Acknowledging limitations imposed by the COVID-19 pandemic is also essential. In Australia, adolescents in high and low lockdown states experienced increased negative emotions (Meyer et al., 2023), poorer mental health, limited physical activity and increased screen time (Gardner et al., 2022b; Goldfeld et al., 2022). Similar patterns were observed overseas (Lawrance et al., 2022). Although *Health4Life* was implemented in 2019, the follow-up assessments coincided with the pandemic, possibly influencing participants' response to *Health4Life* and their ability to apply acquired knowledge and skills.

The study sample included students from independent, public, and Catholic secondary schools across three Australian states, contributing to its diversity. However, most students were born in Australia, of middle or upper SES, and residing in major cities (Champion et al., 2021), potentially limiting generalisability. Moreover, including only inner and outer regional students, with no remote schools, impacts understanding whether *Health4Life* had any differential effects by diverse regional groups. Finally, geographical moderation analysis results for alcohol and tobacco outcomes require cautious interpretation due to wide confidence intervals, primarily attributed to low cell counts and low prevalence of use.

Notwithstanding these limitations, a key strength of the *Health4Life* study is its rigorous cluster RCT design and large sample size, making it one of the most extensive school-based studies of its nature. The meticulous development and implementation of *Health4Life* involved close collaboration with end-users (Champion et al., 2023), ensuring the intervention's relevance and engagement among students and teachers. Moreover, *Health4Life*'s favourable acceptability within a school setting enhances its potential for wider applicability and impact. Future work is underway to refine *Health4Life*'s content to better address the specific needs of low SES and geographically remote adolescents.

5. Conclusions

This study offers valuable insights into how SES and geographical factors interacted with the *Health4Life* intervention's effectiveness in targeting alcohol and tobacco use, dietary intake, knowledge, behavioural intentions, and psychological distress. Generally, outcomes were not influenced by SES and geographical location. However, the exception to this pattern is in diet-related outcomes, with varying effects on poor diet and diet-related behavioural intentions based on participants' geographical location, underscoring the importance of considering regional differences in intervention design and implementation. Co-designing and tailoring interventions is essential to address disparities in chronic disease risk behaviours among disadvantaged adolescent populations. Future research should consider the impact of SES and geographical factors in intervention design and implementation to optimise outcomes and promote health equity.

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CRediT authorship contribution statement

Lyra Egan: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis, Conceptualization. **Lauren A. Gardner:** Writing – review & editing, Supervision, Project administration, Investigation, Conceptualization. **Nicola C. Newton:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization. **Siobhan O'Dean:** Writing – review & editing, Validation, Software, Methodology, Formal analysis, Data curation. **Katrina E. Champion:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The study's statistical analysis code (syntax) and the collected data, which has been de-identified to protect participants' privacy, will be made accessible to other researchers upon request to the corresponding author. Such requests should be accompanied by a valid study protocol and analysis plan. Data sharing will be facilitated after the approval of a proposal by a committee within the current research team, with a signed data access agreement. The informed consent forms can be found in the published protocol (Teesson et al., 2020).

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Ethical approval

The study was conducted in accordance with the ethical standard outlined in the 1964 Declaration of Helsinki, and approved by the University of Sydney (2018/882), the University of Queensland (2019000037), Curtin University (HRE2019–0083), and ethics committees in the relevant school sectors.

Consent to participate

All individual participants required to provide active written consent to participate in the study and were only included in the study if they had parental consent.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2024.102855.

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Appendix D

Process evaluation of the digital Health4Life intervention among a sample of disadvantaged adolescents and teachers

Appendix D

Preface

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Article

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Process evaluation of the digital Health4Life intervention among a sample of disadvantaged adolescents and teachers

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Abstract

Disadvantaged adolescents, including those from lower socioeconomic status (SES) or geographically remote backgrounds, engage in higher rates of risk behaviours, including poor diet, alcohol and tobacco use. While digital interventions targeting lifestyle risk behaviours show potential, few studies have focused on their implementation and relevance for this population. This study conducted a process evaluation of 'Health4Life', a universal school-based digital program targeting multiple behaviours, among a sample of disadvantaged adolescents. Participants were from six schools classified as low SES (Index of Community Socio-educational Advantage percentile score ≤ 25%), and/or regional using the Australian Statistical Geography Standard. Self-reported student (n = 214) and teacher evaluations (n = 16) assessed Health4Life's acceptability, with qualitative questions capturing areas for improvement. Teacher-reported implementation data (n = 16) measured intervention fidelity and feasibility. Quantitative data were analysed using descriptive statistics and open-ended responses were thematically analysed. Compared to the entire sample, this subset of students evaluated Health4Life less favourably (66% versus 75%), with fewer enjoying the stories (63% versus 75%) and planning to use the skills and information (60% versus 70%). Teacher evaluations were mostly positive and aligned closely with the entire sample. Fidelity data also indicated comparable levels of student engagement (~92% versus ~85%). Key themes for refinement included improving content relevance and technical execution to better resonate with disadvantaged adolescents. While teacher evaluations suggest Health4Life is a valuable program in low SES or regional contexts, students' lower ratings indicate refinements are needed. Identified areas for improvement will guide co-designing the program's adaptation to improve effectiveness and relevance for disadvantaged adolescents.

Trial registration: The Health4Life trial is registered with the Australian New Zealand Clinical Trials Registry (ACTRN12619000431123).

Keywords: process evaluation, sociodemographic disadvantage, adolescent health, lifestyle behaviours, prevention, eHealth

Contribution to Health Promotion

- While digital interventions show potential for targeting lifestyle risk behaviours among disadvantaged adolescents, few studies have focused on their implementation and relevance for this population.
- To address this gap, this study conducted a process evaluation of *Health4Life*, a universal multiple health behaviour change intervention, among a sample of disadvantaged adolescents and their teachers.
- The findings highlight the need to adapt and optimize interventions through place-based co-design approaches to ensure effectiveness and relevance to disadvantaged populations.
- This study provides critical insights into designing and delivering interventions for different subgroups, including low SES and regional adolescents.

INTRODUCTION

Research increasingly demonstrates that social determinants, including the contexts in which a person is born, raised and lives, as well as their occupation and access to health resources, are linked to health outcomes (Commission on Social Determinants of Health, 2008; Viner *et al.*, 2012; Spencer *et al.*, 2019; Flavel *et al.*, 2024) including chronic diseases such as cancer, substance use disorders and mental ill-health (Marmot and Bell, 2019; Massouh *et al.*, 2023). Disadvantaged adolescents, including those of low socioeconomic status (SES) or living in geographically remote areas, are particularly vulnerable to experiencing greater chronic disease burden and tend to report higher rates of modifiable lifestyle risk behaviours, including poor diet, and alcohol and tobacco use, than their more

advantaged peers (Australian Institute of Health and Welfare 2020; Gautam *et al.*, 2023). These behaviours are among the highest contributors to chronic disease morbidity and mortality in adulthood and often manifest during adolescence (Akseer *et al.*, 2020). Thus, preventing disadvantaged adolescents' engagement in these modifiable lifestyle risk behaviours is a public health priority and is critical for safeguarding their health and reducing healthcare burden and health inequities.

To achieve this, surmounting social, structural and economical barriers to access and participation in preventive interventions for disadvantaged adolescents is critical (Alliott *et al.*, 2022). School-based digital interventions, delivered through various platforms including computers, internet, mobiles or telephones, leverage adolescents frequent use of technology to reach them in a space they are already engaged with (Australian Bureau of Statistics, 2016–17; Patton *et al.*, 2016; Vogels *et al.*, 2022). Compared to traditional face-to-face interventions, digital interventions overcome socioeconomic and geographic barriers to access by offering accessible and convenient access to evidence-based content, with increased cost-effectiveness and potential for enhanced engagement and fidelity (Newton *et al.*, 2017). Despite evidence supporting their effectiveness among the general population (Champion *et al.*, 2019; Hutton *et al.*, 2020; Newton *et al.*, 2022), it is essential to tailor digital interventions to the needs and skills of disadvantaged adolescents to promote effective engagement (Yardley *et al.*, 2016). This is crucial for facilitating disadvantaged adolescents' participation, particularly as they already face unique challenges to health including stigma (Robards *et al.*, 2018), less social support (World Health Organization, 2016) and poorer access to health services (Australian Institute of Health and Welfare, 2019). Thus, understanding how SES and geographical location influence the implementation and effectiveness of such interventions is crucial. Conducting process evaluations can be highly beneficial in this regard, as they aim to understand implementation and contextual factors that may act as facilitators and/or barriers to participation and influence intervention outcomes across different settings (Moore *et al.*, 2015).

Although digital interventions should ideally be received similarly (i.e. in terms of perceived satisfaction and use) across different socioeconomic groups and geographical locations (e.g. metropolitan and regional areas), disadvantaged adolescents may not benefit as much from interventions as their more advantaged counterparts due to the aforementioned barriers. Thus, process evaluations are critical for determining whether interventions meet the needs of disadvantaged adolescents and for identifying challenges and areas requiring refinement to optimize intervention acceptability and efficacy (Ellard and Parsons, 2010). However, few process evaluations of digital interventions targeting lifestyle risk behaviours among disadvantaged adolescents have been conducted. For instance, in a recent systematic review of digital interventions targeting diet, alcohol and tobacco use among disadvantaged adolescents, only eight of the 14 studies included reported process evaluation outcomes (Egan *et al.*, 2024a). Although most studies reported high participant satisfaction with the interventions, the feasibility, fidelity and acceptability of studies were mixed. Only five of the eight studies reported process evaluations of school-based digital interventions in the USA (n = 3), Spain (n = 1) and Australia (n = 1), with the remaining being community-, family- or clinic-based digital interventions. The Australian-based study was the only study to include process evaluation data from both students and teachers, providing insights on both how the intervention was experienced by the target user (students) and teachers who have a role in supporting the implementation of the intervention in the school-setting. However, data were collected and analysed between 2012 and 2014 and only among low SES boys in New South Wales (NSW), thus pointing at the need for more recent process evaluations that also include disadvantaged adolescents from various geographical locations across Australia. The dearth of process evaluations on this topic highlights a critical gap in understanding the implementation of digital interventions among disadvantaged adolescents.

In a recent process evaluation of *Health4Life*, a universal digital school-based program targeting multiple lifestyle risk behaviours such as poor diet, alcohol and tobacco use, high SES adolescents reported greater odds of using skills they learned from the intervention in the future compared to low SES adolescents (Champion *et al.*, submitted for publication). This suggests that SES may significantly influence the uptake and utilization of intervention components. Although there were no significant differences in learned skills utilization between regional and metropolitan areas, a moderation analysis of *Health4Life* revealed that geographical location moderated the intervention's effect (Egan *et al.*, 2024b). Specifically, in regional areas, adolescents in *Health4Life* reported greater odds of reporting poor diet compared to the control. Although SES has not generally been found to moderate intervention effects on other school-based interventions targeting lifestyle behaviours such as diet (Yildirim *et al.*, 2011) or physical activity (Robbins *et al.*, 2020; Wassenaar *et al.*, 2021). Therefore, additional investigation into the implementation outcomes among disadvantaged adolescents in *Health4Life* is warranted, particularly as these findings point at the complexity of intervention delivery across diverse contexts.

Against this backdrop, this study aims to conduct a comprehensive process evaluation of *Health4Life* among a subsample of low SES and regional adolescents across Australia, and their teachers, to elucidate the acceptability and feasibility of the intervention within these specific demographic contexts. Additionally, it seeks to identify areas for improvement and refinement, ultimately enhancing the intervention's effectiveness and relevance for disadvantaged adolescents.

METHODS

Study design

The full study design and procedure of *Health4Life* are reported in the published protocol (Teesson *et al.*, 2020). Briefly, the Health4Life Study is large cluster randomized controlled trial aimed at reducing chronic disease risk and improving physical and mental health among adolescents that was implemented in 71 secondary schools across Australia in 2019 (6639 participants aged 11–14 years at baseline) (Champion *et al.*, 2023). Data were collected at baseline, post-intervention, 12, 24 and 36 months after baseline via self-report online or hardcopy questionnaires during class, with students and teachers in the *Health4Life* group completing process evaluation measurements at post-intervention. The current study examines a subset of post-intervention process evaluation questionnaire data from students and teachers from low SES and/or regional schools.

Participant details

Seven intervention schools from low SES and/or regional areas were eligible for the current study. Low SES schools

were identified based on their 2019 Index of Community Socio-educational Advantage (ICSEA) percentile score being in the bottom quartile (Australian Curriculum Assessment and Reporting Authority, 2023). ICSEA values, calculated by the Australian Curriculum, Assessment and Reporting Authority (ACARA), indicate a school's relative educational advantage or disadvantage, based on factors such as parental occupation and education, the percentage of Aboriginal and/or Torres Strait Islander student enrolment, and student and school's geographic remoteness. Schools with an ICSEA percentile < 25% were considered more educationally disadvantaged than at least 75% of schools in Australia. Regional school classification included schools outside of major cities according to the Australian Statistical Geography Standard Remoteness Structure, which categorizes regions based on their access to services (Australian Bureau of Statistics, 2021). Accessibility decreases as remoteness increases, with areas classified as *inner regional*, *outer regional*, *remote* or *very remote*.

As no student or teacher data were collected from one of the eligible schools, the final sub-sample comprised six intervention schools. Three of these schools (50%) fell under the category of inner or outer regional, two (33.3%) were classified as low SES only and one (16.7%) met criteria for both regional and low SES classifications. The majority of these schools were government (83.3%) with one being an independent school (16.7%). Five schools were located in NSW (83.3%), and one was in Western Australia (WA) (16.7%).

The Health4Life intervention

Schools allocated to the intervention group implemented *Health4Life* during regular health education classes. The program consists of six co-designed 20-min online modules, ideally delivered 1-week apart with students completing them individually (Champion *et al.*, 2020). Underpinned by social influence, social cognitive and self-determination theories to promote healthy behaviour change, the core component of each module features interactive cartoon storylines addressing health risk behaviours for chronic disease including poor diet, alcohol use, tobacco smoking, physical inactivity, poor sleep and sedentary recreational screen time. The cartoon storylines interweave evidence-based information about health and social consequences of these behaviours, while also promoting resistance skills, normative education and autonomous motivation that underpin behavioural change theory (Michie *et al.*, 2015). After completing each module, students complete short online quizzes to assess their knowledge. To reinforce content covered, factsheets for each module are available to both teachers and students and optional teacher-facilitated activities including online worksheets and homework tasks are provided. Students received personalized web-based feedback after each questionnaire on their adherence to national health guidelines. Additionally, students could access a companion smartphone app for further support and resources (Thornton *et al.*, 2021). An overview of module content is provided in the Supplementary Appendices (p. 3).

Process evaluation measures

Acceptability and areas for improvement

Student evaluation

Based on evaluation surveys from previous school-based prevention trials (Vogl *et al.*, 2009; Newton *et al.*, 2010; Teesson *et al.*, 2017), students completed an online survey featuring eight questions assessing their satisfaction with *Health4Life*, content relatability and program utility. Example questions included, *'Overall, how would you rate the Health4Life program?'* ('Very good', 'Good', 'Average', 'Poor', 'Very poor'), *'How relevant were the stories to experiences in your own life'* ('Completely relevant', 'Somewhat relevant', 'Unsure', 'Somewhat irrelevant', 'Completely irrelevant'), *'How likely are you to use the skills and information taught in the program in your own life'* ('Very likely', 'Likely', 'Unsure', 'Unlikely', 'Very unlikely'). Responses were converted into binary variables to determine positive or unsure/negative evaluations. Two additional open-ended questions asked participants to provide feedback on one positive and one negative aspect of the program, capturing qualitative insights on the facilitators and barriers to program acceptability, respectively. The full student evaluation survey is provided in the Supplementary Appendices on pages 4 and 5.

Teacher evaluation

Teachers completed a 12-question online or hardcopy evaluation survey assessing program satisfaction and quality, ease of implementation and use, student satisfaction and engagement and likelihood of using and recommending *Health4Life*. Example questions included, *'How would you rate the Health4Life program in comparison to other school-based health education programs?'* ('Much better than most programs', 'Better than most programs', 'The same as most programs', 'Worse than most programs', 'A lot worse than most programs'), *'How easy did you find it to implement the Internet-based component of Health4Life program?'* (Very easy', 'Easy', 'Average', 'Difficult', 'Very difficult'), *'How much do you think the students liked the cartoon-based stories?'* ('Liked a lot', 'Liked a little', 'Average', 'Disliked a little', 'Disliked a lot'), *'How likely would you be to use the Health4Life course as a teaching resource in the future?'* ('Very likely', 'Likely', 'Undecided', 'Unlikely', 'Very unlikely'). Two additional open-ended questions asked participants to provide feedback on improving the program could be improved and any additional comments about the modules. The full teacher evaluation survey can be found in the Supplementary Appendices on pages 6–9.

Fidelity and feasibility

Teachers were asked to complete an online or hardcopy version of a teacher logbook survey, to assess whether the six *Health4Life* modules and corresponding intervention components were implemented as intended (fidelity) and the practicality of implementing *Health4Life* (feasibility). The survey included a range of questions focused on several fidelity measures including adherence (i.e. whether students completed the online cartoon storylines for each module, and if teachers reviewed student summaries with their class or instructed students to download them), dose (i.e. the number and selection of activities students completed) and quality (i.e. teachers' perceptions of the level of student engagement for each module). To ensure consistent delivery across all schools, the research team monitored intervention schools' completion of modules via the intervention website and encouraged teachers to dedicate class time for their students to complete the module if it had not been completed in the scheduled week. Lastly, an open-ended question invited teachers to share any

comments or concerns they had about each module. Further details about the questions asked in the teacher logbook survey can be found in the Supplementary Appendices on pages 10–16.

Analysis

Quantitative data were descriptively analysed in IBM SPSS Version 28.0.0.0 (190) to provide sample characteristics information and percentage agreement with quantitative survey item questions. Qualitative analysis of both student and teacher open-ended responses were conducted in Microsoft Excel and followed a codebook thematic analysis approach (Clarke and Braun, 2017; Braun and Clarke, 2021) to further describe the acceptability and feasibility of the intervention among disadvantaged adolescents. This approach was chosen to facilitate multiple team members coding different sections of the data efficiently. For student responses, the researchers immersed themselves in the data, repeatedly reviewing it to gain familiarity. Through an iterative and inductive approach, initial codes were generated and refined to create a codebook prior to discussing it with the authorship team. This codebook was then used to systematically code all open-text student survey responses to allow for a coherent and interpretive analysis of the data. The first author continued to develop themes, which were then reviewed, defined and named collaboratively with the authorship team. Similarly, for teacher responses, the first author coded each open-text response, adjusting codes as needed to describe developing insights of those data. Salient themes with explanatory value were then constructed, defined and named. In collaboration with the authorship team, themes were discussed and further refined resulting in a shared understanding of where the intervention fell short in meeting the needs of disadvantaged adolescents, along with suggestions for improvement.

RESULTS

Of the 364 students attending the six schools in the current study, 214 (58.8%) completed the student evaluation surveys after completing the *Health4Life* program. The mean age of students was 12.77 (SD = 0.48), predominantly identifying as male (67.5%) and based in NSW (96.7%). Further details on student characteristics are reported in the Supplementary Appendices (p. 17). Regarding teacher participation, out of the 25 teachers across these six schools who registered an account on the *Health4Life* website, 14 (56%) completed both the teacher logbook and evaluation survey, two (8%) completed the teacher evaluation survey only and one (4%) completed the teacher logbook only.

Student evaluation

Students' overall response to *Health4Life* was generally positive, with 66.4% (142/214) of students rating *Health4Life* as good or very good. A total of 65.7% (140/213) found the information helpful, and 80.8% (172/213) reported that the skills and information they received in the program will help them to be healthy in the future. However, only 52.1% (111/213) found the stories relevant to their own experiences and 44.1% (94/213) reported that they would recommend *Health4Life* to their friends. Further details about student responses are in the Supplementary Appendices (p. 17).

Based on 213 student responses to 'one good thing' about *Health4Life*, we developed three dominant themes regarding facilitators for *Health4Life* acceptability (summarized in Table 1). Briefly, students commonly expressed appreciation for the educational value of *Health4Life*, citing informative evidence-based information on health concepts, and helpful and practical assistance for making healthy choices. Many found the stories and content engaging, with some describing it as relevant and relatable. Furthermore, students commended the engagement and interactivity of *Health4Life*, perceiving the cartoons conveyed information in an entertaining and accessible way, the program was fun, easy to use and the online format offered convenience and a different learning experience. However, four students reported 'nothing good' about *Health4Life* and 24 responses were indecipherable, suggesting they were potentially disengaged

Table 1: Summary of dominant themes regarding facilitators for Health4Life acceptability from open-ended student responses

Themes and sub-themes	Description	Example quote
Educational value		
Informative (n = 48)	Informative evidence-based information on health-related concepts and the consequences of unhealthy behaviours	'*I really like all the facts and statistics*'
Helpful (n = 41)	Helpful for making healthy choices	'*it can help me in the future to stay healthy*'.
Stories and content		
Stories (n = 23)	Engaging stories—particularly backstory and character development	'*It has a good story line*'
Relevant and relatable (n = 12)	Relevant and relatable to students' lives and interests	'*It was very relevant and it was something the class WANTED to do, not just another bit of school work*'.
Engagement and interactivity		
Cartoons (n = 19)	Cartoons conveyed information in an entertaining and accessible way	'*the cartoons were pretty interesting i could'nt wait until i got into pdhpe so i could continue the story*'
Fun (n = 11)	Fun way to learn, preferable to traditional classwork	'*it was fun but i leart alot*'
Easy (n = 7)	Easy to use and understand concepts taught	'*It was easy to understand because it was a cartoon*'.
Online (n = 4)	Convenient online format without extensive written work	'*use a computer*'

with the program or their response rate was influenced by procedural factors on how the evaluation survey was administered not facilitating quality responses (e.g. they may have been encouraged by their teacher to complete the survey at home if they were not present in class, which has been found to decrease response rates (Bidonde *et al.*, 2023), or they may have had limited time to complete the survey in class due to unexpected circumstances, affecting response quality).

We developed four key themes regarding barriers to *Health4Life* acceptability based on the 214-student open-text responses to 'one bad thing' about *Health4Life* (summarized in Table 2). The overarching theme revolves around the need for improvement in content delivery and the technical execution of the program for this sub-sample of students. A prominent aspect relates to content quality, where some students highlighted issues related to relevance (in contrast to findings above), storyline coherence and perceived certain aspects as boring. Furthermore, there were structural concerns, particularly regarding the length of modules, relevance of questions and contradiction between the program messaging to reduce screen time and increase physical activity when completing the program online during Health and Physical Education lessons. Technical and design-related issues, including website functioning, graphic design and accessibility concerns were frequently reported. Some students expressed overall dissatisfaction with the entire program, while others mentioned the required engagement, such as homework tasks, as a source of discontent. However, 41 responses were indecipherable/nonsensical.

Teacher evaluation

Most of the 16 teachers who completed the teacher evaluation survey rated *Health4Life* positively (14/16; 87.5%) and found the internet-based component easy to implement (14/16; 87.5%). A total of 81.3% (13/16) perceived the cartoon stories held the students' attention well/very well, and considered the educational quality of the additional classroom activities in the online teacher centre to be good to very good (14/16; 87.5%). However, only half would recommend *Health4Life* to others (8/16; 50.0%). Further details of teacher survey responses to quantitative questions are in the Supplementary Appendices (p. 18). In response to how *Health4Life* could be improved for the future some teachers perceived the program was good as is, stating '*I don't think there is anything at this stage that I could suggest, it is a great program*', whereas others provided suggestions regarding accessibility, the user interface and experience, engagement and relevance, timeframe expectations for users and content clarity and appropriateness.

User interface and experience (n = 10)

Similar to students, teachers suggested addressing website glitches as this impacted user experience, and ensuring speech bubble text on cartoon slides fits within borders. They

Table 2: Summary of key themes regarding barriers to Health4Life acceptability from open-ended student responses

Themes and sub-themes	Description	Example quote
Content quality		
Relevance/relatability (*n* = 16)	Lacked relevance, relatable language, diverse perspectives and real challenges students face	'*some of the info doesn't really include country kids*'
Boring (*n* = 15)	Boring aspects including repetitive, slow-paced, overall unengaging content	'*it was boring sometimes*'
Storyline issues (*n* = 14)	Storyline issues including confusing, unrealistic scenarios, lacked long-term character outcomes, potentially encouraged unhealthy behaviours	'*that its cringy*'
Structural concerns		
Too long (*n* = 20)	Modules were too long	'*the modules went for too long i believe there should only be 3-4 modules'.*
Too short (*n* = 11)	Modules were too short, needed more detailed storylines and character development	'*it should go for longer*'
Contradiction between program format and health-promoting messaging (*n* = 5)	Contradiction between *Health4Life* promoting physical activity and reduced screen time when using screens for program	'*you are telling us to be more active yet we spend hours on a screen completing the activities*'
Technical and design issues		
Website functioning (*n* = 13)	Website functioning issues including slow loading times, glitches and lag	'*The lag and glitches of the website*'
Graphic design (*n* = 11)	Unappealing graphic design including character style, and text outside speech bubble borders	'*Bad graphics*'
Accessibility (*n* = 8)	Accessibility impacted by too much text, lack of voice overs and reliance on internet access	'*not all people can read or have internet*'
Overall dissatisfaction		
Everything (*n* = 5)	Everything is unsatisfactory	'*all of it*'
Required engagement (*n* = 3)	Required engagement with materials including homework participation	'*being made to do it as homework*'

recommended removing the repetitiveness of student worksheets, making them dynamic and embedding them within the *Health4Life* platform to eliminate the need for printing. Moreover, teachers proposed adding minimum time requirements for each cartoon slide to assist with getting students to work at similar paces and prevent them skipping ahead without engaging with the content. Although teachers noted that questions and interactive activities embedded within the modules helped engage students.

> *Found it hard to stop some students from skipping through the cartoon without reading it properly. The use of questions and interactive activities through the online modules engaged the students.* (Teacher)

Teachers also suggested streamlining administrative tasks by increasing teacher account privileges for resetting student passwords quickly and efficiently and the ability to set generic passwords for individual classes.

Engagement and relevance (n = 5)

Teachers praised the engaging stories that seamlessly integrated essential information, whilst maintaining student interest across different ability levels. However, some expressed that despite *Health4Life* providing students with potential benefits, student apathy towards new learning experiences is common, indicating a need for a more engaging program. A few teachers discussed variations in student engagement and module completion, with students either racing through independently or struggling to finish them.

> *The engagement and completion of modules depended on the ability of students. Some students raced through and even completed the modules at home (even though they had been told to complete them in class) while other students did not complete all modules….* (Teacher)

Content clarity and appropriateness (n = 5)

Teachers suggested improving content clarity and assessing the appropriateness of some content. Specifically, concerns were raised regarding the difficulty in understanding some of the questionnaires, particularly the sleep questionnaire. Additional feedback included perceiving some activities as overly simplistic and requiring further information to improve their educational value, more content or longer lessons to cover one school term and redistributing the workload across the modules as some had too much content and activities whereas others were lacking. Therefore, a thorough review and testing of all materials are needed to ensure they address these concerns effectively.

> *We found some modules had too much content/activities and others didn't have enough for a whole lesson. Perhaps adjusting the amount of work in some lessons would improve ….* (Teacher)

Accessibility (n = 4)

Some teachers noted limited access to computer labs in certain schools, which could impact participation for students without personal devices. Others commented on the challenge of balancing using the program as prescribed with catering to individual student learning needs. Moreover, they discussed the importance of voiceovers to accompany the cartoon slides, not only to support students with lower literacy levels but also to improve engagement. Therefore, an offline or adapted format may be necessary to overcome these issues to ensure *Health4Life* is accessible to students with diverse backgrounds and learning needs.

> *Audio options for students who have poor reading skills.* (Teacher)

> *… Easy to access and use. My school each high school student has to have a device so makes access easy- in other schools where this is not the case it may have proved harder to access computer labs.* (Teacher)

Timeframe expectations for users (n = 2)

Lastly, teachers mentioned discrepancies between advised and actual module completion timeframes, indicating more accurate instruction is required to aid in lesson planning. Some teachers facing time constraints chose to double up lessons to cover the curriculum. To ensure more teachers understand the realistic timeframes and program format flexibility, and accommodate varying time constraints, clear documentation of this must be included in the program implementation guide available to teachers.

> *… we were told around 20 minutes per module- realistically it took around 40 minutes for our Year 7 students to read each module. Just advising of a more realistic timeframe.* (Teacher)

Teacher fidelity

Teacher logbook data collected from 16 teachers are reported in Supplementary Appendix Table 6 (p. 19). Most teachers indicated that the cartoon storylines were fully completed, except for modules 5 and 6, primarily due to lack of time. Teachers reported students were somewhat to very engaged 85.7–100% across modules, with the greatest engagement reported for module 3 (100%). Module 3 also had the most reviewed summary sheets for students and teachers (93.3%). Module 4 demonstrated the highest completion rates for both the online interactive activity (86.7%) and the three offline activities (88.9%). None of the recommended/homework tasks across modules were fully completed. Teachers expressed concerns about accessibility, login issues and too much content in module 1, while module 2 feedback pertained to graphic design issues affecting text readability and the need for more content. Modules 5 and 6 were positively reviewed, with module 5 complimented for its engaging activities, particularly the interactive sleep hazards activity, while module 6 was commended as a '*good summative lesson*' (Teacher).

DISCUSSION

Few studies have reported on process evaluations of school-based digital interventions targeting poor diet, alcohol use and tobacco smoking among disadvantaged adolescents (Egan *et al.*, 2024a), leaving a significant gap in the literature regarding the implementation and relevance of such interventions for this population. The current study reports on the implementation of a universal school-based digital program targeting multiple behaviours among disadvantaged adolescents

in Australia. The *Health4Life* intervention received positive feedback from both teachers and students, yet only half of teachers and 44.1% of students expressed intentions to recommend the program to others. This is in contrast to the process evaluation among the entire sample which demonstrated a more positive overall experience and higher rates of recommendation (Champion *et al.*, submitted for publication). This highlights the need to adapt and optimize interventions with the distinct population in mind. Several areas for improvement and refinement were identified in the present study to improve the effectiveness and relevance of the intervention for disadvantaged adolescents.

Compared to process evaluation findings from the entire sample, this sub-sample of students evaluated *Health4Life* less favourably. For instance, a smaller proportion of students rated the program positively (66% versus 75% among the entire sample), enjoyed the stories (63% versus 75%), found the information helpful (65% versus 76%), were likely to use the skills and information in their own life (60% versus 70%), and would recommend *Health4Life* to friends (44% versus 50%). Despite the sub-sample of students in the current study reporting that the entertaining online cartoons made health messaging accessible, these lower ratings suggest the program has limited relevance for disadvantaged adolescents. Interestingly teacher evaluations of *Health4Life* in this study aligned closely with those of the entire sample and were mostly positive. Teacher fidelity data were also comparable to the entire sample, with similar levels of student engagement (~92% versus ~85%) and slightly more activities completed per module (3 versus 2). However, only 50% of these teachers would recommend *Health4Life* to others compared to 64% in the entire sample. The discrepancy may reflect teachers' recognition of *Health4Life*'s value and potential in low SES or regional contexts where comparable programs may be scarce, whilst acknowledging the need for content and technical delivery improvements which was also noted in the entire sample process evaluation, alongside *Health4Life*'s limited contextual relevance for disadvantaged adolescents. These findings are consistent with other school-based digital interventions for disadvantaged adolescents. A recent systematic review reported that while participants generally expressed high satisfaction with the interventions, the feasibility, fidelity and acceptability of studies were mixed (Egan *et al.*, 2024a). For instance, in one study (Smith *et al.*, 2014; Lubans *et al.*, 2016) only 44% agreed or strongly agreed they enjoyed using the intervention app, potentially due to limited engaging features and lack of co-design. Another study (Nollen *et al.*, 2014) reported high enjoyment scores (mean = 4.5/5; SD = 0.9) and participant engagement with the program on 63% of days, which may be due to conducting in-depth co-design with the target population and addressing their needs. It is worth noting that the teacher-reported fidelity data regarding students' *Health4Life* module completion (i.e. 85.7–100% completed module cartoon storylines) is similar to intervention completion of other school-based digital programs among disadvantaged adolescents (Egan *et al.*, 2024a). These completion rates coupled with high teacher-reported rates of student engagement (~92%) are positive particularly as engagement is a key element for improved intervention effects, albeit only 64% (16/25) of teachers completed the teacher logbook.

Themes developed from the qualitative data in the current study revealed key issues resonating with challenges faced by low SES/regional adolescents. For instance, students critiqued *Health4Life*'s content quality and relevance of stories to their own experiences. They raised structural concerns about the program's length and the requirement to engage with *Health4Life* via computers during health education classes, which seemed discordant with its healthy behaviour messaging. Both students and teachers criticized the accessibility of the program for diverse backgrounds and literacy levels, echoing broader challenges low SES and regional adolescents face. Differences in digital literacy among adolescents from different socioeconomic backgrounds, including how they access and use technology, may have shaped how relevant the intervention was to them. Indeed, Lim *et al.* (2024) have suggested that low SES adolescents engage with digital media differently compared to their more advantaged peers, which may influence their digital literacy. For example, in one study (Harris *et al.*, 2017) there were differences in computer use among a sample of adolescents in Western Australia. Specifically, low SES adolescents were less likely to access computers in school than high SES adolescents. Additionally, they were more likely to use their home computer for non-academic activities such as chat rooms and multimedia (e.g. video and music). Whereas high SES adolescents used their home computer learning programs to improve their academic skills. Considering this, incorporating support mechanisms such as greater visual material and chatbots may be potentially helpful features to compensate for SES differences (Maenhout *et al.*, 2022).

Nevertheless, this study identified refinements needed to improve the student and teacher experience, including: adding dynamic features (e.g. embedding activity worksheets); more appropriate content (e.g. addressing repetitive worksheets); clearer documentation of program flexibility to accommodate time constraints; improving accessibility (e.g. voiceovers, reducing text on screen); fixing issues such as website glitches and text overflowing borders; setting minimum time requirements on cartoon slides to ensure students work at similar paces and granting teachers greater administrative privileges (e.g. reset passwords easily). For improved implementation suggested refinements include: balancing the workload across modules (e.g. content redistribution and additional materials for certain modules), catering better to diverse learning needs and environments (e.g. offering flexible delivery modes with more offline content) and providing resources to improve digital literacy (e.g. such as step-by-step instructions on how to log in and use the website—both written and via a recorded video—, adding a chatbot to allow for instant assistance). These points suggest that without adapting *Health4Life* to disadvantaged adolescents' context, their sustained engagement and the program's utility may be compromised.

Indeed, adapting *Health4Life* to the specific skills, needs and barriers of disadvantaged adolescents is essential for ensuring its relevance and for promoting effective engagement with the intervention (Yardley *et al.*, 2016). This requires contextual adaptation leveraging co-design approaches, including disadvantaged adolescents and their teachers as support, to appropriately address feedback and refine the program content, delivery methods and engagement strategies. Involving both students and their teachers in the adaptation process is important as they may experience the program differently. For instance, the program's design and format may align more closely with teachers' pedagogical perspectives on targeting lifestyle risk behaviours among adolescents than with

the students' real-life experiences. Nonetheless, considering that teachers facilitate the implementation of *Health4Life* with their students, ensuring their experience is seamless and enjoyable is paramount to its success.

Although *Health4Life* was co-designed with students and teachers, recruitment for this development phase lacked a representative mix of schools with varying SES and geographic distribution, predominantly involving metropolitan and more affluent schools. This may partly explain the less favourable process evaluation outcomes in the current study. Nevertheless, moving forward, the co-design adaptation process with disadvantaged adolescents and their teachers should be iterative with development and implementation intertwined to allow for ongoing refinement and facilitate participation. Al-Dhahir *et al.* (2022) identified this approach as a facilitator in digital lifestyle intervention participation among low SES adults, and it could have addressed early issues with *Health4Life* teachers in the current study mentioned, including student difficulties with logging in and registering. Confidentiality and privacy concerns are also important factors to consider. They have been identified as prerequisites for participation in digital mental health programs among vulnerable young people, specifically school leavers, which is associated with experiencing socioeconomic disadvantage (Kuosmanen *et al.*, 2018). Furthermore, incorporating the broader social networks of disadvantaged adolescents, including parents and peers may improve the acceptability and feasibility of the intervention. This is because peers can influence adolescent behaviours and peer-led interventions can be effective at targeting lifestyle risk behaviours (Veenstra and Laninga-Wijnen, 2022). Similarly, parental factors and behaviour modelling can influence adolescent behaviours (e.g. dietary composition) and parent-based interventions delivered alongside school-based programs have shown success in improving adolescent outcomes (Champion *et al.*, 2022; Osman *et al.*, 2024). The *Health4Life* team are currently evaluating the accompaniment of a parent-based program with *Health4Life* among disadvantaged adolescents.

Strengths and limitations

This study has several strengths, including gathering detailed feedback from both disadvantaged students and their teachers to provide an understanding of *Health4Life*'s acceptability for this demographic and areas for refinement. The inclusion of schools from diverse regions, including resource-constrained settings, enhances the relevance of the findings across various educational contexts. The mixed-methods approach, combining quantitative data (e.g. program ratings) with qualitative feedback enriched the analysis to provide deeper insights into how and why *Health4Life*'s acceptability and implementation differed for disadvantaged adolescents. These findings have important implications for designing and delivering interventions to different subgroups, including low SES and regional adolescents.

However, there are some limitations. Teachers from one inner regional independent WA school did not complete the teacher logbook nor the teacher evaluation survey, limiting comparative analysis with the one outer regional WA school that provided data. The WA teachers who provided data only completed the teacher evaluation and did not submit any teacher logbook data, restricting our understanding of *Health4Life* in this region. The use of teacher-led surveys may have introduced response bias, with potentially more engaged and motivated teachers actively providing evaluation and logbook data. Thus, future studies should triangulate data with objective measures (e.g. from the intervention website) to corroborate teacher survey responses and provide information for teachers who do not complete the surveys. Only one author coded qualitative teacher data which may have limited richness of analysis, although thematic analysis does not always require multiple reviewers (Byrne, 2022). Finally, the findings may not be fully generalisable due to the limited number of schools and regions involved in the study. Future research with a broader sample is needed to validate these results.

CONCLUSION

This study addresses a notable gap in the literature by examining the implementation and relevance of a universal school-based digital intervention targeting lifestyle risk behaviours among disadvantaged adolescents. The findings reveal key areas for refinement including improving content relevance and technical execution to better resonate with disadvantaged adolescents, and ensuring accessibility for students with diverse backgrounds and learning needs. Future iterations of *Health4Life* should leverage iterative co-design approaches involving both disadvantaged adolescents and teachers to refine the program and ultimately enhance its engagement, relevance and effectiveness. The implications of the study findings have broader applicability in providing valuable guidance for optimizing the design and implementation of digital interventions among diverse populations.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Health Promotion International* online.

AUTHOR CONTRIBUTIONS

N.C.N. and K.C. provided funding acquisition. L.A.G., N.C.N. and K.C. provided supervision and project administration. L.E., L.A.G., N.C.N. and K.C. conceptualized the study. L.E. drafted the manuscript. All authors were involved in reviewing and editing the manuscript. All authors read and approved the final version of the manuscript and agreed to publication.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this article.

DATA AVAILABILITY

The data underlying this article cannot be shared publicly for the privacy of individuals who participated in the study.

ETHICS APPROVAL

The Health4Life Study was conducted in accordance with the ethical standard outlined in the 1964 Declaration of Helsinki, and approved by Human Research Ethics Committees of the University of Sydney (2018/882), the University of Queensland (2019000037), Curtin University (HRE2019-0083) and relevant school sector ethics committees.

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Appendix E

A mixed-methods study among adolescents and teachers in Bogotá, Colombia: Adapting the OurFutures Alcohol Program

Appendix E

Preface

This mixed-methods study has been published as:

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LE led the development of this paper. The authors are LE, L-OP, KEC, NCN, PVBA, MT and LAG. All authors conceptualised the study. LE secured funding for this study and acquired ethical approval. L-OP, KEC, NCN, MT and LAG provided supervision. LE, L-OP and PVBA were responsible for data collection and project administration. LE developed the methodology, and LE and PVBA conducted formal analysis and interpretation of data. LE wrote the original manuscript. All authors were involved in the review, read and approved the final version and agreed to publication.

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Article

A mixed-methods study among adolescents and teachers in Bogotá, Colombia: adapting the OurFutures Alcohol Program

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Abstract

Early onset of alcohol consumption among Colombian adolescents highlights the need for effective and accessible preventive interventions. This project aimed to conduct formative work to inform the adaptation of an effective eHealth alcohol use prevention program originally developed in Australia, the *OurFutures Alcohol Module*, to the Bogotá context. Twenty-six adolescents and 10 teachers in Bogotá participated in the study. We used a mixed-methods approach comprising interviews, surveys and semi-structured discussions to evaluate the acceptability of OurFutures. Study materials were translated into Spanish before conducting three 1.5-hour focus groups with adolescents (aged 11–15; $n = 26$), and 1-hour interviews or online surveys with teachers to assess attitudes towards alcohol use and the acceptability of one lesson from the *OurFutures Alcohol Module* in the Bogotá context. Qualitative data were analysed thematically, and descriptive analyses of quantitative data reported percentage agreement for survey questions. Overall, 96% of students and 89% of teachers expressed strong satisfaction with the *OurFutures Alcohol Module* lesson. Most students (96%) liked its storyline and character portrayal, and most teachers (80%) said they would use *OurFutures* with their students. Participants provided feedback for improving program relatability, including adapting scenarios, character names, clothing and language to align with the Bogotá context and resonate with Colombian adolescents. This study marks the first step in informing the adaptation of the *OurFutures Alcohol Module* to the Bogotá context and highlights key considerations for cultural adaptations of other substance use prevention interventions. This research underscores the importance of place-based end-user involvement in co-designing adolescent prevention interventions.

Keywords: Colombia, prevention, alcohol, eHealth, adolescents, mixed-methods approach, adaptation

Contribution to Health Promotion

- Colombian national survey data has reported early alcohol use initiation among adolescents, yet standardized alcohol prevention programs are lacking in Colombian schools.
- This study formatively assessed the acceptability of one lesson of the *OurFutures Alcohol Module*, an effective eHealth school-based alcohol use prevention program originally developed in Australia, within the Bogotá context.
- The findings provide evidence that, with appropriate adaptation involving co-design with place-based end users, the *OurFutures Alcohol Module* could be an acceptable and engaging alcohol prevention strategy in the Bogotá context.
- This study offers valuable insights and recommendations for developing culturally tailored preventive interventions.

INTRODUCTION

Alcohol consumption during adolescence is associated with increased risk of alcohol-related harms and future substance use (Ryan *et al.*, 2019; Hamidullah *et al.*, 2020; Australian Institute of Health and Welfare, 2021). According to the 2019 Colombian National Survey on the Use of Psychoactive Substances (ENCSPA), 46.3% of young people aged 12 to 17 years had consumed alcohol at least once, with 12.1% over the past 30 days (National Administrative Department of Statistics. DANE, 2020). Alarmingly, the average age of first alcohol consumption among this cohort is 13.9 years. Initiation at 14 years or younger among Colombian youth has been associated with two-and-a-half times the risk of hazardous alcohol use and four times the risk of substance

use in adulthood, compared to those who first consume alcohol at 18 years (Pérez Gómez *et al.*, 2011). This trend aligns with Australian findings, where earlier initiation is associated with hazardous drinking at a younger age (Gardner *et al.*, 2023). According to the recent WHO Global Status Report on Alcohol and Health and Treatment of Substance Use Disorders (World Health Organization, 2024), 23.7% of young people aged 15–19 years in Colombia are current drinkers, which is higher than in neighbouring countries such as Guatemala (17.4%) and Honduras (19.6%). Additionally, 12.4% of young Colombians aged 15–19 years report binge drinking, defined as consuming 60 grams or more of pure alcohol (equivalent to six standard drinks) at least once in the past month. Although the 12.4% rate of binge drinking among young Colombians is lower than in neighbouring countries such as Argentina (28.3%), it remains a significant public health concern (World Health Organization, 2024). Binge drinking among young people is associated with acute consequences such as alcohol poisoning, motor vehicle accidents and violence, as well as long-term consequences including alterations to general brain functioning and substance use dependence (Kuntsche *et al.*, 2017; World Health Organization, 2024). Factors that may influence drinking patterns in Colombia include cultural and social normalization of alcohol consumption, positive attitudes towards alcohol, and low-risk perception (Londoño-Pérez and Carrasco-Aravena, 2019). Early intervention and prevention is therefore critical for safeguarding the health of Colombian youth.

School-based alcohol prevention interventions are an effective approach for delivering long-lasting health and economic benefits (Kuklinski *et al.*, 2021; Newton *et al.*, 2022). Ensuring successful delivery of prevention interventions involves careful consideration of available resources (e.g. personnel, training, and financial costs), and the target population's needs. Given approximately one in four of the Colombian population lives in rural regions (National Administrative Department of Statistics. DANE, 2022), electronic health (eHealth) interventions (e.g. computer-, web-, mobile-, or telephone-based) may be a viable option as they can be accessed remotely and at little cost to the end user, and provide increased implementation fidelity and student engagement (Newton *et al.*, 2017). There is substantial evidence to support the effectiveness of school-based eHealth interventions in reducing alcohol use and intentions to use alcohol (Voogt *et al.*, 2013; Hutton *et al.*, 2020; Martinez-Montilla *et al.*, 2020; Kazemi *et al.*, 2021; Newton *et al.*, 2022). However, to our knowledge, there are currently no school-based eHealth interventions targeting alcohol use among Colombian youth, nor are there standardized alcohol prevention programs established in Colombian schools.

Developing a sustainable and effective prevention intervention can be expedited by building upon evidence-based programs known to be effective at driving behaviour change. The Australian *OurFutures prevention model* (formerly known as Climate Schools) has been used to develop a suite of web-based substance use prevention programs for school-aged students. The *OurFutures* model was developed by researchers at Australian universities funded by government and philanthropic grants. The development involved collaboration with students, teachers, and health and education experts, aimed at offering programs that overcome barriers to implementing high-fidelity programs to address the critical need for early prevention of substance use (Newton *et al.*, 2009; Vogl *et al.*, 2012). Based on a harm minimization and social influence approach, the core component of the program utilizes interactive online cartoon storyboards to engage and educate students, with optional teacher-facilitated activities to reinforce the core content. The *OurFutures* programs have been rigorously evaluated across eight large cluster randomized controlled trials in Australia (240 schools, >21 000 students, up to 7-year follow-up), demonstrating effectiveness in preventing the uptake and harmful use of alcohol and other drugs, reducing harms related to alcohol and other drugs, and improving attitudes towards alcohol among Australian adolescents (Newton *et al.*, 2020; Slade *et al.*, 2020), up to 7 years after intervention delivery (Newton *et al.*, 2022). This model offers promise for international adaptation, with adapted versions already developed for multiple countries, including the UK (Newton *et al.*, 2014) and Germany (Röhrig *et al.*, 2023). However, recognizing that the *OurFutures Alcohol Module* was originally designed for Australian adolescents aged 13–14 years, and the average age of first alcohol consumption in Colombia is 13.9 years, potential adjustments for earlier delivery may be warranted to align with the cultural and developmental context of Colombian adolescents.

Considering the diversity of Colombia's regions, Bogotá, the nation's capital and largest city, stands out as an ideal starting point for conducting this formative work. With over 8 million inhabitants from various parts of the country, Bogotá's diverse population presents an opportunity to encounter a broad spectrum of races and cultures on a smaller scale (National Administrative Department of Statistics. DANE, n.d.). To ensure the acceptability and feasibility of the *OurFutures Alcohol Module* within the Bogotá context, we first require an understanding of the individual, interpersonal and cultural beliefs associated with alcohol consumption among Bogotán youth (Londoño-Pérez and Carrasco-Aravena, 2019) and feedback from young people and teachers on the program in its current form. Collaborating with and including end users in the intervention design process is crucial, as it can influence the development, engagement and outcomes of an intervention (Slattery *et al.*, 2020). Therefore, the aim of this study was to seek feedback from Bogotán young people and teachers as a first step towards guiding the adaptation of an effective eHealth school-based prevention program (*OurFutures Alcohol Module*) for the Bogotá context.

METHODS

Study design

This study followed a mixed-methods case-study design, collecting data from focus group sessions with students and interviews or online surveys with teachers. This approach was chosen based on established frameworks and methodologies for effective adaptation led by team members N.C.N., M.T. (Newton *et al.*, 2014) and L.O.-P. (Ospina-Pinillos *et al.*, 2020), facilitating a comprehensive exploration of participant attitudes toward alcohol use, the acceptability of *OurFutures* and identifying areas of improvement to suit the Bogotá context. This study was approved by the University of Sydney Human Research Ethics Committee (HREC 2022/875) and Research and Ethics Committee of Pontificia Universidad Javeriana (HREC 2023/105).

Participants and recruitment

One school in Bogotá was invited to participate via an invitation letter to the school principal in July 2023. This specific school was chosen due to established professional relationships between the school and the research team and because they had previously expressed interest in participating in research studies. The school is a large public school catering to students attending Preschool, Primary School (grades 1–5), Lower Secondary School (grades 6–9), and Upper Secondary School (grades 10–11). The school primarily serves populations facing socioeconomic disadvantage, including those experiencing economic hardship and migrants. This context is particularly significant as research indicates that socioeconomic disadvantage is associated with increased substance use, including alcohol consumption (Degenhardt *et al.*, 2016). Therefore, selecting this school allowed for the provision of evidence-based resources to an underserved population that may have limited access to prevention programs, and the findings may therefore be especially important for populations at higher risk of alcohol use.

Eligible participants were adolescents aged 11–15 years proficient in Spanish for focus groups, and teachers for interviews or online surveys. Students from grades 5–7 were selected by their teachers to participate, and information about the study was disseminated to school staff via the primary contact. Two additional teachers from separate secondary schools in Bogotá were recruited following L.O.-P.'s lecture to Master of School Mental Health students, where the study was promoted to ensure a sufficient number of teachers participated in the study. Adolescents were required to obtain written parental consent and give their assent to participate, and teachers were required to provide active consent. As reimbursement for their time, students received scholarly goods valued at COP$30.000 (approximately AUD$10) and teachers received a COP$50.000 (approximately AUD$17) voucher for their time.

Procedures

Study materials, including focus group and interview guides, online surveys for adolescents and teachers, and an alcohol factsheet for adolescents, were translated by a native English speaker fluent in Spanish (L.E.). These translations were then reviewed by an official Spanish translator to ensure accuracy, followed by review for linguistic and cultural relevance by the Colombian researchers (L.O.-P. and P.V.B.A.). The *OurFutures Alcohol Module* was translated into Spanish using the in-built translation software, 'Kanzi', on the *OurFutures* website. As a precaution for potential internet connectivity issues at the participating school or for teachers, one lesson was also downloaded as a hardcopy PDF version. Subsequently, between August and October 2023, focus groups and interviews were facilitated in Spanish by the research team (L.E., L.O.-P., P.V.B.A.), guided by a semi-structured format, and audio-recorded for transcription. All surveys were administered in Spanish via REDCap.

Three 1.5-hour student focus groups were held at the secondary school in Bogotá. Part one of each session explored participants' attitudes and perceptions towards alcohol use. Subsequently, participants reviewed one lesson from the *OurFutures Alcohol Module* and provided feedback on the program's relatability and acceptability within the Bogotá context. Towards the end of the session, participants completed a brief evaluation survey and commented on the acceptability of an age-appropriate debrief alcohol factsheet. Participants could keep the debrief factsheet, which contained factual information about alcohol including its effects and potential risks of alcohol consumption during adolescence, as well as contact information for L.O.-P. should they require further information. L.O.-P. is a registered psychiatrist and was available as part of duty of care protocols to guide participants towards appropriate help if needed. Additionally, participants were provided with contact details for separate support services accessible via email, WhatsApp or over the phone, ensuring they had access to helpful resources.

Teachers reviewed one lesson from the *OurFutures Alcohol Module* prior to participating in the 1-hour Zoom interview or online survey (based on their preference). Both the interview and survey featured similar questions as detailed in Supplementary Appendices pg. 7–32. Part one of the interview or online survey focused on attitudes and perceptions about alcohol consumption among young Colombians and alcohol education in Colombian schools. Subsequently, teachers provided feedback on the relatability and acceptability of the *OurFutures Alcohol Module* lesson within the Bogotá context.

Materials

The *OurFutures Alcohol Module* is a universal eHealth school-based program, originally developed for Australian adolescents aged approximately 13–14 years. Consisting of six cartoon-based lessons with accompanying teacher-facilitated activities aimed at decreasing alcohol misuse, the module is embedded within the school health curriculum and requires no formal teacher training. A summary of lesson content is provided in Supplementary Appendices (pg. 2).

Due to poor internet speed at the participating school, a lesson from the *OurFutures Alcohol Module* was provided as a hardcopy PDF version in Spanish for all focus group sessions. Most participating teachers evaluated the same hardcopy PDF version for this reason, with the exception of two teachers from different schools who reviewed the lesson via the *OurFutures* website. Focus group participants received a printed one-page alcohol factsheet to review and keep (see Supplementary Appendices pg. 3–4). The focus group and interview guides, and online surveys administered to adolescents and teachers, can be found in Supplementary Appendices (pg. 5–36).

Analysis

Quantitative data were analysed using R version 4.2.2. Descriptive analyses were performed to report sample characteristics and percentage agreement for each survey item. Qualitative data including transcripts from focus groups and interviews, along with collected open-ended survey data were analysed using reflexive thematic analysis in NVivo by two researchers (L.E. and P.V.B.A.) to construct key themes and insights (Braun and Clarke, 2006; Terry *et al.*, 2017; Braun *et al.*, 2023). The research team adopted an experiential orientation to the data by coding significant quotes independently and then discussing coding differences to improve reflexivity and develop richer interpretations, before developing and grouping meaning-driven themes. This inductive approach allowed for participant-driven discussion priorities, ensuring a genuine representation of feedback. Data were anonymized to protect confidentiality. L.E. and P.V.B.A. recognized their

varying assumptions that may have influenced the analysis. L.E., a native English speaker with Spanish as a second language and substantial experience in Australian research contexts, particularly in chronic disease risk behaviours among young people, may have brought a broader, more external perspective to the research. In contrast, P.V.B.A., a native of Bogotá with extensive research experience in Colombia among diverse population groups and research topics, contributed a localized interpretation likely influenced by their lived experience in Bogotá. While these perspectives enriched the analysis, they also reflect the subjectivity inherent in L.E. and P.V.B.A.'s roles as researchers.

RESULTS

A total of 26 students from grades 5, 6, and 7 participated in three focus groups. Most adolescents identified as male (59%) and were aged between 11 and 15 years (M = 12.7 years; SD = 1.2). A total of 10 teachers participated, with 3 opting for interviews and 7 completing the online survey. Among these teachers, 8 were from the same school as the focus group participants, and 2 were from two other schools in Bogotá. The participants' teaching experience ranged from 8 to 28 years (M = 19.9 years; SD = 8.4).

Part 1: Student and teacher attitudes and perceptions towards alcohol use

Quantitative data from the teacher surveys and interviews revealed that all teachers (10/10; 100%) perceived that drinking alcohol was common among Colombian youth and that it co-occurs with other risk behaviours. More than half (6/9; 67%) perceived alcohol consumption patterns as similar across different geographical locations (cities vs rural areas); however, only 40% (4/10) perceived alcohol consumption patterns as similar across different socioeconomic status levels. Awareness of evidence-based alcohol prevention resources for young Colombians was limited (1/10; 10%); however, most teachers (8/10; 80%) reported a high likelihood of using such programs if available. Refer to Supplementary Appendix Table 3 pg. 37 for further details.

Table 1 summarizes the four key themes that were generated from the student focus group discussions and teacher interviews/surveys, revealing shared perspectives of the cultural significance of alcohol. Detailed insights are available in Supplementary Appendices (pg. 38–40). Socioeconomic status was identified as having a greater influence than geographical differences on the initiation age and type of alcohol consumed. Despite awareness of health impacts and risks, one teacher emphasized the low-risk perception of alcohol in Colombian society, especially among minors.

Part 2: Relatability and acceptability of *OurFutures* within the Bogotá context

Student and teacher data from focus groups and interviews/surveys provided in-depth insights on the acceptability of *OurFutures* within the Bogotá context, including its potential integration into alcohol prevention curriculum in Colombia. This information is described in the following six themes.

(i) *The unique landscape of alcohol prevention in Bogotá schools*

Most teachers reported being unaware of evidence-based alcohol prevention courses for young people in Colombia. Although training based on evidence offered by external organizations such as the Health Department was mentioned, concerns were also expressed about existing programs funded by the alcohol industry and potential conflicts of interest.

Table 1: Summary of key themes related to student and teacher attitudes and perceptions towards alcohol consumption among young Colombians

Theme	Description	Example quote
Cultural significance of alcohol	Alcohol plays a prominent role in Colombian culture, often present in celebrations and gatherings. Early exposure is common, and may be viewed by parents as promoting responsible consumption.	'*Unfortunately, alcohol is part of Colombian culture, it's seen in any kind of gathering, … it's considered normal for children and teenagers to consume alcoholic beverages at family gatherings, with some saying it's better for them to get used to it*'. (Teacher 6)
Developmental stages and initiations	Alcohol consumption among young people is perceived as common. Initiation often occurs in family settings, with minimal geographical variations. Urban areas offer diverse alcoholic beverages, while rural areas have traditional drinks. Socioeconomic status influences onset age and type of alcohol consumed.	'*Alcohol consumption among young Colombians normally first occurs in family spaces, … [rather than] differences in consumption by geographical locations, … what changes in the socioeconomic strata is the type of liquor consumed, well children from low socioeconomic strata consume more beer or low-priced liquor, while those in higher socioeconomic strata consume higher quality and priced liquor*'. (Teacher 3)
Alcohol consumption influences and practices	Student-perceived motivations for alcohol consumption included depression, seeking independence, rebellion and curiosity. Social modelling—witnessing adults and peer consume alcohol—influences experimentation with alcohol. Students and teachers discussed commonality of combining alcohol with substances including cocaine, cannabis and cigarettes.	'*… you also see several young people, and it seems that the others inspire them to try that, and well, they seem to like it, … and they keep trying it*'. (Grade 6 focus group)
Health awareness and risk perception	Students perceived immediate risks when young people consume alcohol including violence. Grades 6 and 7 extend concerns to long-term dangers, including cancer. However, some teachers discussed a low-risk perception in Colombian society, especially among minors, attributed to family influence.	'*… people's risk perception scales regarding how serious consuming alcohol is, it is inversely proportional. Among all drugs, alcohol has the lowest risk perception, around 10% or a little less. This high frequency of consumption, especially among minors, is often linked to family influence*'. (Teacher 1)

Table 2: Key recommendations from teachers and students to integrate and improve the *OurFutures Alcohol Module* for the Bogotá context

Theme	Recommendations
(i) The unique landscape of alcohol prevention in Bogotá schools	The program must be relatable to young Colombians, engaging and effectively address the negative impacts of early alcohol consumption to encourage teachers to use the program with their students.
(ii) The language needs to be contextualized	Incorporate familiar and culturally relevant language. Avoid overly technical or refined language. Consider integrating jargon and using everyday language used by young Colombians.
(iii) Aligning alcohol representation in *OurFutures* with Colombian context	Adjust the portrayal of alcoholic beverages to better resonate with Colombian culture. Substitute instances of characters drinking vodka with locally familiar drinks like 'Aguardiente' and common beer brands.
(iv) Narrative elements and character diversity	Enhance character representation and story elements to align with the Colombian context. Address concerns about the perceived affluence of existing characters. Modify scenes to include diverse and realistic characters, avoiding beauty stereotypes and unrealistic scenarios.
(v) Educational content	Ensure the content's appropriateness for different age groups from different schools, as some situations may not be suitable for all students.
(vi) Teachers appreciate the flexibility in delivery but call for improvements	Provide additional activities. Ensure platform efficiency and consider the inclusion of follow-up sessions, ongoing evaluation and continuous support and feedback for students.

> '*Based on evidence, I only know about this one. I also know about training offered by the Pan American Health Organization in Colombia, along with the Health Department of Bogotá.*' (Teacher 1)

Alcohol education approaches varied among teachers, with no standardized alcohol prevention curriculum in Colombian schools. Some teachers described delivering it based on their judgement, using resources they found online, or involving external psychologists. Conversely, others outlined a comprehensive curriculum starting in fifth grade, covering various dimensions related to alcohol.

> '*Schools provide information for prevention purposes, but the program depends on each institution.*' (Teacher 8)

> '*…two psychologists from the … Health Department come. They conduct group activities focused on the theme of prevention, … as a whole group intervention. The intervention involves dynamics, games, and discussions about the topic. In cases of specific instances of consumption, we refer them to [the hospital] for further assistance …*' (Teacher 2)

> '*… In our school, we start in the fifth grade, focusing on identifying protective factors, … We begin by talking about alcohol, touching on the risks at a physical and cerebral level … In the sixth grade, we delve a bit more into the social dimension, in the seventh grade, into the biological dimension, in the eighth grade, into the dimension of human relationships, and in the ninth grade, we integrate it more.*' (Teacher 1)

Teachers expressed readiness to adopt evidence-based alcohol prevention programs with their students if they were relatable, available, engaging and effectively addressed negative effects of early alcohol consumption.

Turning to the acceptability of the *OurFutures Alcohol Module*, the results from both student and teacher questionnaire data indicated it was generally received positively, with most students (25/26; 96%) and teachers (8/9; 89%) rating the lesson they reviewed as good or very good. Additionally, students reported a strong liking for the storyline (25/26; 96%) and characters (25/26; 96%). Generally, teachers agreed (9/10; 90%) that the educational content within the *OurFutures Alcohol Module* is appropriate for Colombian youth, and that they would use this program with their students (8/10; 80%). Further details on student and teacher acceptability data can be found in Supplementary Appendices (pg. 41).

Analysis of qualitative data (focus group and interview discussions, and open-text responses) supported findings from the questionnaires. Students generally rated the *OurFutures Alcohol Module* lesson highly stating they liked the story, and teachers generally endorsed the program, citing its preventive approach and potential to destigmatize discussions on alcohol.

> '*I would use the proposed program as it allows us to approach the subject in a preventive way and would eliminate the taboo that exists to talk to students about the topic of alcohol consumption.*' (Teacher 3)

The positive feedback, however, was accompanied with recommendations for improvement, particularly in terms of cultural contextualization (summarized in Table 2).

(ii) *The language needs to be contextualized*

Teachers and students emphasized the importance of using familiar and culturally relevant language in *OurFutures*. While some teachers perceived the existing language as relatable, others felt it was occasionally too technical. Suggestions included incorporating jargon and changing alcohol-related terms to align with everyday language used by young Colombians.

> '*It is necessary to recognise and use vocabulary that is familiar to young Colombians.*' (Teacher 3)

> '*…here in Colombia, we say "trago," [equivalent to booze in English] "chorro," "aguardiente," nothing too refined or delicate when talking about alcohol … and I see that in the cartoons, there was a language that was either too technical or too refined…*' (Teacher 2)

> '*It would be very important to have the Colombian accent, the physical appearance of the characters, and their names, also the fashion…*' (Grade 7 focus group)

Students proposed culturally relatable alternatives for character names, including 'Sebastián' for Mike, 'Valentina' for Jane, 'Tomás' for Tom, 'Sara' for Claire, and 'David' for Dave. Moreover, they recommended integrating colloquial

or Bogotán expressions to substitute words that may not resonate well with Colombian audiences. For instance, they identified the term 'guay' ('cool' in English) as characteristic of Spanish from Spain, suggesting more typical Colombian expressions to replace it, including 'chévere'.

(iii) *Aligning alcohol representation in OurFutures with the Bogotá context*

Students recommended aligning the depiction of alcoholic beverages in *OurFutures* with Colombian culture. Suggestions included swapping instances of characters drinking vodka with locally familiar drinks such as 'Aguardiente' (brandy in English), premixed drinks, and common beer brands. Only grade 5 students discussed a preference for mixing beer with sweets, a trend they observed on TikTok.

'There wouldn't be vodka, rather aguardiente…' (Grade 7 focus group)

(iv) *Narrative elements and character diversity*

Students and teachers expressed concerns regarding the misalignment of character representation and storyline elements within the Bogotá context. Despite appreciating some characters, students desired more characters and criticized the perceived affluence of existing ones. Recommendations included changes to clothing, hairstyles and broader diversity in appearances to better represent people of their age.

'*They were very posh, I would change that.*' (Grade 5 focus group)

Teachers echoed the need for more realistic and diverse characters, expressing concerns about beauty stereotypes and relationship portrayals.

'*There were some little things that bothered me, I feel that there are some beauty stereotypes…the only one with a boyfriend in the group is the slim cute girl.*' (Teacher 1)

Both students and teachers suggested modifying beach scenes (more aligned with Australian contexts) to park environments to better resonate with youth in Bogotá. Students also critiqued a scene involving characters riding a shopping trolley as unrealistic, suggesting alternatives such as riding bikes. Teachers proposed including locations where young people consume alcohol such as family gatherings to better reflect social dynamics in Colombia. While some scenarios were praised by teachers, with one stating they appreciated *OurFutures'* effort in presenting realistic situations, others raised concerns, particularly regarding the portrayal of absent parents.

'*…it somewhat contradicts what parents might expect. I think, while the situation, for example, about girls drinking, one's mother being absent, the context of absent parents—parents are absent, but not absent like that…*' (Teacher 1)

(v) *Educational content*

Teachers generally appreciated the clarity and appropriateness of the content, and commended its diverse representation of authority figures extending beyond the police. This broad representation was perceived as an effective strategy to raise awareness about decision-making and social influence. However, one teacher perceived a lack of religious or spiritual elements, and others expressed concerns about the advanced content, deeming it inappropriate for certain age groups.

'*Yes, the educational content, because it's a matter of raising awareness about decision-making … I found it interesting that they didn't only portray the police as [the only] authority figure … authority figures are also at home, parents, guardians, here at school, teachers, counsellors, coordinators … I consider that part of the pedagogical sense is very well framed.*' (Teacher 2)

'*It is very advanced for the age of the children.*' (Teacher 9)

'*…I'm also a homeroom teacher for seventh grade, ranging from 13 to 14 years old; it wouldn't work at all. The content is a bit advanced, and in terms of the situation, showing them that might open windows they're not ready for yet. They wouldn't understand the situations very well.*' (Teacher 1)

(vi) *Teachers appreciate the flexibility in delivery but call for improvements*

Teachers expressed diverse perspectives on the *OurFutures* format. Some valued the 20-min cartoons as the core component and flexibility in completing optional activities, deeming this format suitable for class schedules, especially when time constraints are a concern. Conversely, some called for additional activities, whereas others found the format lengthy and wanted more dynamic and engaging elements. The two teachers who reviewed *OurFutures* via the website said the platform was slow.

'*…it was cool that the central part was 20 minutes, I think that's what you can take advantage of in a class. In my classes, they are 50 minutes long, and in the end, between discipline, behaviour issues, what ends up being used in a class is about 20 minutes, … doing more activities is a bit ambitious …*' (Teacher 1)

Other recommendations from teachers included incorporating follow-up sessions, continuing evaluation for enhanced learning outcomes, and providing ongoing support and feedback.

'Follow-up and not abandoning the program.' (Teacher 4)

'Feedback and ongoing evaluation.' (Teacher 5)

DISCUSSION

This study formatively assessed the acceptability of one lesson from the *OurFutures Alcohol Module* in the Bogotá context, as well as participant attitudes and perspectives underpinning alcohol consumption among young Colombians to better understand how to guide the adaptation of the program. By gathering insights from Colombian young people and teachers, this study represents the initial step towards informing the adaptation of an effective eHealth school-based program for the Bogotá context. Feedback from 26 students in 3 focus

groups and 10 teachers through surveys (7 teachers) and interviews (3 teachers) highlighted the significant impact of cultural and social factors on attitudes toward alcohol among young Colombians. It underscored the importance of programs such as the *OurFutures Alcohol Module* in their context. While overall participants found the *OurFutures Alcohol Module* lesson acceptable and provided positive feedback about the program, several recommendations were made to enhance its cultural relevance. This emphasizes the need for refinements based on participant feedback to ensure optimal effectiveness and resonance within the Bogotá context.

A prevalent theme was the cultural significance of alcohol in Colombian society, with participants discussing its ubiquitous presence in celebrations and gatherings, synonymous with social enjoyment. Participants collectively acknowledged these events as early and normalized exposures for young Colombians. Thus, the consensus among participants on the commonality of alcohol consumption among young Colombians was unsurprising, and also aligned with the 2019 ENCSPA Colombian National Survey findings (National Administrative Department of Statistics. DANE, 2020). Teachers also perceived that geographical and socioeconomic factors influence adolescents' alcohol preferences, however, emphasized the added impact of socioeconomic status on alcohol initiation among young Colombians. This underscores the importance of universal alcohol prevention interventions portraying variations in alcoholic beverages for relevance in both urban and rural areas, and across socioeconomic status levels. Furthermore, offering earlier program delivery is crucial, particularly due to the earlier age of first alcohol use in Colombia compared to Australia (National Administrative Department of Statistics. DANE, 2020).

The *OurFutures Alcohol Module* is well-suited to address these issues, employing a harm minimization and social influence approach, coupled with attributes associated with positive prevention outcomes (UNODC/WHO, 2018; Ogden and Hagen, 2019). This approach involves providing evidence-based information about alcohol use and associated harms, normative education to correct misperceptions, and resistance skills training. As students cited various motivations for alcohol consumption, ranging from curiosity, seeking independence and social modelling, where young people imitate the alcohol-related behaviours observed in adults and peers [which is consistent with Yuen *et al.* (2020) findings on peer influence in alcohol use], *OurFutures*' focus on social influence aligns with the experiences articulated by students. Furthermore, *OurFutures* aligns with the 2019 Colombian Comprehensive Policy for Psychoactive Substance Use, which advocates for capacity building within educational communities, strengthening coping skills to resist social pressures related to substance use and supporting the implementation of evidence-based harm reduction strategies (Ministry of Health and Social Protection, 2019).

Teachers discussed the unique landscape of alcohol prevention in Colombian schools, noting a lack of standardized alcohol prevention curricula with varying approaches among them for implementing such education, and limited teacher awareness of evidence-based resources (10%). Most teachers (80%) expressed a high likelihood of using a tailored digital alcohol education program, contingent on relatability, availability and engagement. Together, these observations highlight the imperative of tailoring the *OurFutures Alcohol Module* to the Bogotá context, particularly as most teachers were unaware of evidence-based programs and some of the only programs teachers referenced were funded by the alcohol industry, which have been reported as problematic for minors (Robaina *et al.*, 2020).

Student focus group and teacher interview/survey insights into the relatability and acceptability of *OurFutures* within the Bogotá context, demonstrated that overall, *OurFutures* was rated positively, with 96% of students and 89% of teachers rating the lesson highly. Additionally, 96% of students liked the storyline and characters. Most teachers (90%) perceived the content as reasonable and showed a willingness to deliver the program with their students (80%). Both groups identified key areas for improvement, which the research team will address through a detailed, iterative, co-design process, including language contextualization, adjusting depiction of alcoholic beverages to align with Colombian culture, incorporating diverse and realistic characters, modifying narrative elements, adjusting educational content for different age groups, and refining the program format.

Regarding language contextualization, teachers and students stressed the importance of using familiar, colloquial vocabulary and culturally relevant expressions. This includes adjusting alcohol-related terms to match everyday language used by young Colombians, updating character names with culturally relevant alternatives, and integrating colloquial expressions to replace terms that may not have translated well or reflected vocabulary from Spain rather than Colombia. Given the variation in Spanish lexicon between Colombia and Spain (Ardila, 2020), accurate and culturally appropriate language use is essential. Thus, a meticulous language adaptation process, such as the one outlined by Maríñez-Lora *et al.* (Maríñez-Lora *et al.*, 2016) that involves not only forward translation but also back-translation and harmonizing the translation to confirm it reflects the original meaning is warranted.

Both students and teachers highlighted the misalignment of character representation and story elements with the Bogotá context, seeking more realistic and diverse characters, critiquing the perceived affluence of existing ones and suggesting changes to clothing, hairstyles, and broader diversity. As feedback was gathered from public school students, the affluence concern may not apply to students from schools in more affluent areas of Bogotá. Nevertheless, to address these considerations, a collaborative approach involving the co-design of new characters with youth in Bogotá is necessary to ensure authenticity and relevance. Modifying unrealistic scenes was perceived as important by both groups to ensure cultural relevance, with recommendations including shifting from beach to park environments—considering Bogotá's landlocked nature—and including family gatherings as settings for alcohol consumption among youth in Bogotá, aligning with participants' views on the cultural normalization of alcohol in such situations. Teachers additionally expressed concerns about beauty stereotypes and relationship depictions, which are crucial to address in the cartoons. Adolescence is a formative period where individuals are developing their identities and self-perceptions (Ogden and Hagen, 2019). Adolescent exposure to unrealistic beauty standards can contribute to body image issues and negatively impact self-esteem and mental health (McBride *et al.*, 2019). Diverse portrayals of relationships can influence adolescents' understanding of healthy relationships, fostering positive social dynamics and interpersonal skills (Vaterlaus *et al.*, 2018; Taba *et al.*, 2020; West *et*

al., 2021). Therefore, it is essential to address these concerns through co-design with youth in Bogotá, so that the content remains engaging and relevant, ultimately promoting adolescents' overall wellbeing.

Teachers typically appreciated the educational content's clarity and appropriateness, especially the inclusion of various authority figures beyond police, encompassing parents, teachers and counsellors, which is characteristic of the comprehensive approach adopted in *OurFutures*. Concerns raised by a teacher about the inappropriateness of the advanced content for certain age groups suggest comprehensive content testing with school students from diverse backgrounds to align with students' developmental stages is required. This ensures relevance without compromising educational integrity, as delivering the program at a later age would not precede the average onset of alcohol consumption in Colombia. Although careful consideration of the appropriateness of the content for younger age groups is warranted. Teacher feedback on the *OurFutures* format varied, with some valuing the 20-min cartoons and flexibility, while others finding it lengthy and desiring more dynamism. As most teachers reviewed the PDF version of the cartoons, it is challenging to gauge whether their opinions would remain consistent when viewing the cartoons on the website. Although the website was not without issue as two teachers expressed concerns about the poor platform speed, emphasizing the need for optimized website performance outside of Australia. Additional recommendations included follow-up sessions, continuous evaluation and ongoing support for enhanced learning outcomes.

Limitations and strengths

It is crucial to interpret the study findings within the context of certain limitations. Despite Bogotá being the most populous and largest city in Colombia, the study findings may not fully capture the country's regional diversity. Furthermore, the involvement of only one public school for the focus groups may limit representation of the diverse student population both in Bogotá and across Colombia. However, it was important to collaborate with this school as it served disadvantaged adolescents, offering a unique opportunity to offer essential resources to support the needs of this underserved population. A key strength of *OurFutures* is that it is built on complex models of behaviour change that are embedded within the storylines of the cartoons to engage and maintain student interest and involvement, with significant intervention effects in Australia (Newton *et al.*, 2020, 2022; Slade *et al.*, 2020). However, as the applicability of the behaviour change principles underpinning *OurFutures* in the Bogotá context was not explored in the current study, the next phase of program adaptation could assess these principles' relevance in a cross-cultural context and examine the contextual nuances influencing behaviour change outcomes in educational settings. Additionally, while this study focused on reviewing one lesson from the *OurFutures Alcohol Module*, which was sufficient for the purposes of the current study—intended as the first step in guiding the adaptation of the *OurFutures Alcohol Module* to the Bogotá context—future research should involve testing the entire module with young Colombians and teachers to gain a broader understanding of its effectiveness, cultural adaptability and potential impact in the Bogotá context. Despite certain limitations, the use of quantitative and qualitative data in this study aided in contextualizing and strengthening the findings for a better understanding of the cultural adaptation of the *OurFutures* program within the Bogotá context. Additionally, this study, through the collection of valuable feedback from Bogotá youth and teachers, serves as an essential step towards informing the adaptation of an effective eHealth school-based alcohol prevention program for the Bogotá context. Such a program is currently non-existent, yet critical, particularly considering the absence of standardized alcohol prevention education in Colombia. Moving forward, additional consultations with students and teachers will be conducted to further refine and enhance the program.

CONCLUSION

This study marks the first step in informing the adaptation of an effective eHealth alcohol prevention program to the Bogotá context by gathering feedback from young Colombians and teachers. The implications of the study extend to the broader field of alcohol prevention in Colombian schools, with the identified challenges and recommendations providing valuable insights for developing culturally tailored preventive interventions. The findings provide evidence that the *OurFutures Alcohol Module* could be an acceptable and engaging alcohol prevention strategy in the Bogotá context, once appropriately adapted. The next steps involve incorporating participant feedback into the iterative adaptation of the *OurFutures* program, ensuring its relevance in the Bogotá context, and evaluating the feasibility of the program. Collaboration with place-based end-users, ongoing evaluation and a commitment to cultural sensitivity will be crucial in shaping a sustainable and impactful alcohol prevention initiative for young Colombians.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Health Promotion International* online.

AUTHOR'S CONTRIBUTIONS

L.E. acquired the funding. L.O.-P., K.E.C., N.C.N., M.T., and L.A.G. provided supervision. L.E., L.O.-P., K.E.C., N.C.N., M.T., and L.A.G. conceptualized and designed the study. L.E., L.O.-P., and P.V.B.A. were responsible for data collection and project administration. L.E. and P.V.B.A. conducted formal analysis and interpretation of data. L.E. drafted the manuscript. All authors were involved in reviewing and editing the manuscript. All authors read and approved the final version of the manuscript and agreed to publication.

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CONFLICT OF INTEREST STATEMENT

M.T. and N.C.N. are directors of Climate Schools Pty Ltd, and co-founders and directors of OurFutures Institute, a Not-For-Profit established to enable distribution of OurFutures to schools in Australia. This did not influence the work reported in this paper.

ETHICS APPROVAL

This study was conducted in accordance with the ethical standard outlined in the 1964 Declaration of Helsinki, and approved by the University of Sydney Human Research Ethics Committee (HREC 2022/875) and Research and Ethics Committee of Pontificia Universidad Javeriana (HREC 2023/105).

DATA AVAILABILITY

The data underlying this article cannot be shared publicly for the privacy of individuals who participated in the study.

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Appendix 1

Supplementary materials for Chapter 2

Appendix 1.1: Primary Outcomes Survey Instruments

Diet-related variables survey questions

Section 4: What You Eat & Drink

43. Looking at the image below, please indicate **how many cups** of the following drinks you usually consume:

1 small glass, small can or standard popper **= 1 cup**	1 standard can or small bottle **= 1.5 cups**	1 standard bottle (600ml) **= 2.4 cups**	1 family size bottle (1.25L) **= 5 cups**

Please tick ONE option only for each question:

	Never/ Rarely drink	1 cup or less a **WEEK**	2 to 4 cups a **WEEK**	5 to 6 cups a **WEEK**	1 cup a **DAY**	1½ cups or more a **DAY**	2 or more cups a **DAY**
Plain water (tap or bottled)							
Fruit juice							
'Diet' soft drink or diet cordial, such as Diet Coke or Sprite or Coke Zero. ***Do not include energy drinks.***							
Soft drink, cordials or sports drinks (such as Coke, lemonade, Ribena or Gatorade). ***Do not include energy drinks.***							

44. Please indicate **how often** you usually drink Energy drinks (e.g. Mother, V, Red Bull)

Please tick ONE option only for each question:

	Never/ Rarely	1 or less times a **WEEK**	2 to 4 times a **WEEK**	5 to 6 times a **WEEK**	Once a **DAY**	2 or more times a **DAY**
Small can/bottle (less than 500mls)						
Big can/bottle (500mls or more)						

45. How many serves of fruit do you usually eat each day?
1 serve = 1 medium piece or 2 small pieces of fruit or 1 cup of diced / frozen pieces

2 small pieces

1 medium piece

1 cup of diced or frozen pieces

I don't eat fruit	Less than 1 serve per day	1 serve per day	2 serves per day	3 serves per day	4 serves per day	5 serves per day	6 serves per day	More than 6 serves per day	Don't know

46. How many serves of vegetables do you usually eat each day?
1 serve = 1/2 cup cooked / canned / frozen vegetables (including legumes) or 1 cup of salad vegetables

1/2 cup cooked vegetables

1/2 cup canned or frozen vegetables

1 cup of salad vegetables

I don't eat vegetables	Less than 1 serve per day	1 serve per day	2 serves per day	3 serves per day	4 serves per day	5 serves per day	6 serves per day	More than 6 serves per day	Don't know

Section 21: What You Eat & Drink

215. On school days, where do you usually eat breakfast?

- ○ At home
- ○ On the way to school
- ○ At school
- ○ Other _____
- ○ I don't usually eat breakfast

216. Please indicate **how often** you usually have the following foods:						
Please tick ONE option only for each question:						
	Never/ Rarely	1-2 times a **WEEK**	3-4 times a **WEEK**	5-6 times a **WEEK**	Once every **DAY**	2 or more times a **DAY**
Hot chips, French fries, wedges or fried potatoes						
Potato crisps or other salty snacks (such as Twisties or corn chips)						
Snack foods, such as sweet and savoury biscuits, cakes, donuts or muesli bars						
Confectionary, such as lollies or chocolate						
Ice cream or ice blocks						
Takeaway meals or snacks from places like McDonald's, Hungry Jack's, Dominos, KFC, Red Rooster, Oporto, Pizza Hut or local takeaway food places						

Alcohol-related variables survey questions

Section 6: Alcohol

For the next set of questions, please look at the 'Standard Drinks Guide' below. When you hear the term 'standard drink' your first reaction may be to think of a standard glass or bottle. By definition, a standard drink contains approximately 10 grams of alcohol. For example, one full strength can of beer contains 1.4 standard drinks. Remember, cocktails, punch, and other mixed drinks can contain several standard drinks.

55. About what proportion of your friends and acquaintances drink any alcohol at all (even a sip)?

- ○ All or almost all
- ○ More than half
- ○ About half
- ○ Less than half
- ○ None

56. About what proportion of your friends and acquaintances drink alcohol to get drunk?

- ○ All or almost all
- ○ More than half
- ○ About half
- ○ Less than half
- ○ None

57. Have you ever had a sip of alcohol?

- ○ Yes
- ○ No (If no, skip to Q75)

58. Have you consumed any alcohol (even counting a sip or a taste) in the past 6 months?

- ○ Yes
- ○ No

59. Have you ever had a *full standard alcoholic drink* (see alcohol chart)?

- ○ Yes
- ○ No (If no, skip to Q75)

60. Have you had a *full standard alcoholic drink* (see alcohol chart) in the past 6 months?

- ○ Yes
- ○ No (If no, skip to Q63)

61. How often did you have a *standard alcoholic drink* of any kind in the past 6 months?

- ○ Never (If never, skip to Q63)
- ○ Less than monthly
- ○ Once a month
- ○ 2-3 times a month
- ○ Weekly
- ○ Daily or almost daily

62. In the past 6 months, how many *standard drinks* did you have on a typical day when you were drinking alcohol?

- ○ None
- ○ 1-2
- ○ 3-4
- ○ 5-6
- ○ 7-9
- ○ 10+

63. Have you ever consumed 5 or more *standard alcoholic drinks* (see chart above) on one occasion?

- ○ Yes
- ○ No (If no, skip to Q65)

64. How often did you have 5 or more *standard alcoholic drinks* on one occasion in the past 6 months?

- ○ Never
- ○ Less than monthly
- ○ Once a month
- ○ 2-3 times a month
- ○ Weekly
- ○ Daily or almost daily

65. In the past 6 months, what is the maximum number of standard drinks you have consumed on one occasion? (leave blank if you haven't had any standard drinks in the past 6 months)

- ○ 1-2
- ○ 3-4
- ○ 5-6
- ○ 7-10
- ○ 11-19
- ○ 20+

Tobacco-related variables survey questions

Section 7: Smoking

The next four questions ask about cigarette (tobacco) smoking.

80. Have you ever tried smoking a cigarette, even one or two puffs?

- ○ Yes
- ○ No (If no, skip to Section 8: E-Cigarettes and Vaping)

81. In the past 6 months, have you tried cigarette smoking, even one or two puffs?

- ○ Yes
- ○ No (If no, skip to Section 8: E-Cigarettes and Vaping)

82. During the past 30 days, on how many days did you smoke cigarettes?

- ○ 0 days (skip to Section 8: E-Cigarettes and Vaping)
- ○ 1 or 2 days
- ○ 3 to 5 days
- ○ 6 to 9 days
- ○ 10 to 19 days
- ○ 20 to 29 days
- ○ All 30 days

83. During the past 30 days, on the days you smoked, how many cigarettes did you smoke per day?

- ○ Less than 1 cigarette per day
- ○ 1 cigarette per day
- ○ 2 to 5 cigarettes per day
- ○ 6 to 10 cigarettes per day
- ○ 11 to 20 cigarettes per day
- ○ More than 20 cigarettes per day

Vaping-related variables survey questions

Section 8: E-Cigarettes and Vaping

The next questions ask about use of e-cigarettes, sometimes known as vapes, vaping, vape pens, vaporizers, electronic cigarettes, e-cigars, e-pipes, pods, Juul, electronic nicotine delivery systems (ENDS), puff bars, e-shisha, and e-hookah. These are battery-operated devices that hold and heat e-liquids that emit vapours which the user inhales.

84. About what proportion of your friends and acquaintances have used e-cigarettes (even one or two puffs)?

- ○ All or almost all
- ○ More than half
- ○ About half
- ○ Less than half
- ○ None

85. If your friend offered you a vape, how likely would you be to try it?

- ○ Certain not to try
- ○ Very unlikely/unlikely
- ○ Undecided
- ○ Likely/very likely
- ○ Certain to try

86. Have you ever used an e-cigarette, even one or two puffs?

- ○ Yes
- ○ No (If no, skip to Section 9: Future You)

87. At what age did you first use an e-cigarette?

- ○ Age 10 or below
- ○ Age 11
- ○ Age 12
- ○ Age 13
- ○ Age 14
- ○ Age 15
- ○ Age 16
- ○ Age 17 or above

88. When did you last use e-cigarettes?

- ○ In the past day (24 hours)
- ○ More than 1 day ago, but within the past 7 days
- ○ More than 7 days ago, but within the past 30 days
- ○ More than 1 month ago, but within the past 3 months
- ○ More than 3 months ago, but within the past 6 months
- ○ More than 6 months ago, but within the past 12 months
- ○ More than 12 months ago

89. How frequently did/do you use e-cigarettes?

- ○ Just tried them once, haven't used again
- ○ Once a month or less
- ○ Three or more days in the past month
- ○ Weekly
- ○ Daily

90. When you most recently used e-cigarettes, what did you most commonly vape?

- ○ Flavour only – no nicotine
- ○ Nicotine + flavour
- ○ Nicotine alone
- ○ Don't know / didn't choose

91. When you most recently used e-cigarettes, where did you most commonly obtain them from?

- ○ Friends
- ○ Parents (without permission)
- ○ Parents (with permission)
- ○ Purchased online
- ○ Purchased in person at a store
- ○ Other: _____

92. Which did you use first, e-cigarettes or tobacco cigarettes?

- ○ I have not used tobacco cigarettes
- ○ Tobacco first
- ○ E-cigarettes first
- ○ Started both at the same time

Appendix 1.2: STROBE cross-sectional reporting checklist

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	#3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	#4	Present key elements of study design early in the paper	7
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	N/A
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-12
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for exposed and unexposed groups if applicable.	8-12
Bias	#9	Describe any efforts to address potential sources of bias	N/A
Study size	#10	Explain how the study size was arrived at	8
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	12
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	12
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	N/A
Statistical methods	#12c	Explain how missing data were addressed	8
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	12
Statistical methods	#12e	Describe any sensitivity analyses	N/A
Results			

Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	N/A
Participants	#13b	Give reasons for non-participation at each stage	N/A
Participants	#13c	Consider use of a flow diagram	N/A
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	8
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	-
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	N/A
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	13-16
Main results	#16b	Report category boundaries when continuous variables were categorized	-
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	#18	Summarise key results with reference to study objectives	17
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	20
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	17-20
Generalisability	#21	Discuss the generalisability (external validity) of the study results	20
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	22

Appendix 1.3: Risk behaviours among participants present at 36-month post-baseline follow-up in the Health4Life trial, grouped by disadvantaged versus more advantaged participants

Risk behaviour	**Whole sample (N = 4445)**	**Disadvantaged sub-sample (N = 896)**	More **advantaged sub-sample (N = 3549)**
SSB consumption			
More than 5 cups (N [% [95% CI]])	444/4272 (10.4% [9.5,11.3])	112/853 (13.1% [11.0,15.6])	332/3419 (9.7% [8.8,10.7])
Fruit intake			
Insufficient fruit (N [% [95% CI]])	1508/4273 (35.3% [33.9,36.7])	309/854 (36.2% [33.0,39.5])	1199/3419 (35.1% [33.5,36.7])
Vegetable intake			
Insufficient vegetable (N [% [95% CI]])	3708/4272 (86.8% [85.7,87.8])	719/854 (84.2% [81.6,86.5])	2989/3419 (87.4% [86.3,88.5])
Discretionary food intake			
Excessive (N [% [95% CI]])	1621/3960 (40.9% [39.4,42.5])	279/775 (36.0% [32.7,39.4])	1342/3185 (42.1% [40.4,43.9])
Full standard drink in previous 6 months			
Did consume full standard drink	1263/4225 (29.9% [28.5,31.3])	251/844 (29.7% [26.8,32.9])	1012/3381 (29.9% [28.4,31.5])
Binge drink in previous 6 months			
Did binge drink	569/4207 (13.5% [12.5,14.6])	115/842 (13.7% [11.5,16.1])	454/3365 (13.5% [12.4,14.7])
Tobacco smoking in previous 6 months			
Did smoke tobacco cigarette	334/4212 (7.9% [7.2,8.8])	86/834 (10.3% [8.4,12.6])	248/3378 (7.3% [6.5,8.3])
Use e-cigarette in previous 6 months			
Did use e-cigarette	671/4206 (16.0% [14.9,17.1])	126/835 (15.1% [12.8,17.7])	545/3371 (16.2% [15.0,17.4])

Appendix 1.4: Sample characteristics among participants present at 36-month post-baseline follow-up in the Health4Life trial, grouped by relative Low SES versus Mid to High SES levels

	Low SES (N = 571)	**Mid to High SES (N = 3518)**
Age (mean [SD])	15.70 (0.55)	15.71 (0.65)
Gender identity (N [%])		
Male	326 (57.2%)	1641 (46.8%)
Female	215 (37.7%)	1708 (48.7%)
Non-binary	17 (3.0%)	101 (2.9%)
Prefer not to say	12 (2.1%)	59 (1.7%)
Psychological distress (N [%])		
No	441 (81.7%)	2662 (79.8%)
Yes	99 (18.3%)	674 (20.2%)
State (N [%])		
NSW	358 (62.7%)	1874 (53.3%)
QLD	127 (22.2%)	1015 (28.9%)
WA	86 (15.1%)	629 (17.9%)
Socio-economic status (N [%])		
Low	571 (100%)	0 (0%)
Mid	0 (0%)	1529 (43.5%)
High	0 (0%)	1989 (56.5%)
Geographical location (N [%])		
Major city	497 (87.0%)	3235 (92.0%)
Regional	74 (13.0%)	283 (8.0%)

Appendix 1.5: Risk behaviours among participants present at 36-month post-baseline follow-up in the Health4Life trial, grouped by relative Low SES versus Mid to High SES levels

	Low SES (N = 571)	Mid to High SES (N = 3518)
SSB consumption		
More than 5 cups (N [% [95% CI]])	76/550 (13.8% [11.2,17.0])	322/3386 (9.5% [8.6,10.5])
Fruit intake		
Insufficient fruit (N [% [95% CI]])	210/551 (38.1% [34.2,42.2])	1169/3386 (34.5% [32.9,36.1])
Vegetable intake		
Insufficient vegetable (N [% [95% CI]])	468/551 (84.9% [81.7,87.7])	2952/3386 (87.2% [86.0,88.3])
Discretionary food intake		
Excessive (N [% [95% CI]])	187/513 (36.5% [32.4,40.7])	1317/3173 (41.5% [39.8,43.2])
Full standard drink in previous 6 months		
Did consume full standard drink	135/547 (24.7% [21.2,28.5])	1024/3355 (30.5% [30.0,32.1])
Binge drink in previous 6 months		
Did binge drink	54/546 (9.9% [7.7,12.7])	456/3340 (13.7% [12.5,14.9])
Tobacco smoking in previous 6 months		
Did smoke tobacco cigarette	50/539 (9.3% [7.1,12.0])	250/3347 (7.5% [6.6,8.4])
Use e-cigarette in previous 6 months		
Did use e-cigarette	73/540 (13.5% [10.9,16.7])	528/3343 (15.8% [14.6,17.1])

Appendix 1.6: Sample characteristics of participants present at 36-month post-baseline follow-up in the Health4Life trial, grouped by geographical location

	Regional (N = 399)	**Major City (N = 4046)**
Age (mean [SD])	15.73 (0.5)	15.71 (0.65)
Gender identity (N [%])		
Male	229 (57.5%)	1943 (48.2%)
Female	152 (38.2%)	1913 (47.4%)
Non-binary	10 (2.5%)	113 (2.8%)
Prefer not to say	7 (1.8%)	66 (1.6%)
Psychological distress (N [%])		
No	286 (79.7%)	3063 (79.9%)
Yes	73 (20.3%)	771 (20.1%)
State (N [%])		
NSW	212 (53.1%)	2186 (54.0%)
QLD	187 (46.9%)	1212 (30.0%)
WA	0 (0%)	648 (16.0%)
Socio-economic status (N [%])		
Low	74 (20.7%)	497 (13.3%)
Mid	173 (48.5%)	1356 (36.3%)
High	110 (30.8%)	1879 (50.4%)
Geographical location (N [%])		
Major city	0 (0%)	4046 (100%)
Regional	399 (100%)	0 (0%)

Appendix 1.7: Risk behaviours among participants present at 36-month post-baseline follow-up in the Health4Life trial, grouped by geographical location

	Regional (N = 399)	Major City (N = 4046)
SSB consumption		
Excessive/more than 5 cups (N [% [95% CI]])	47/373 (12.6% [9.6,16.4])	397/3899 (10.2% [9.3,11.2])
Fruit intake		
Insufficient fruit (N [% [95% CI]])	125/373 (33.5% [28.9,38.4])	1383/3900 (35.5% [34.0,37.0])
Vegetable intake		
Insufficient vegetable (N [% [95% CI]])	309/373 (82.8% [78.7,86.3])	3399/3900 (87.2% [86.1,88.2])
Discretionary food intake[7]		
Excessive (N [% [95% CI]])	117/327 (35.8% [30.8,41.1])	1504/3633 (41.4% [39.8,43.0])
Full standard drink in previous 6 months		
Did consume full standard drink	141/366 (38.5% [33.7,43.6])	1122/3859 (29.1% [27.7,30.5])
Binge drink in previous 6 months		
Did binge drink	74/365 (20.3% [16.5,24.7])	495/3842 (12.9% [11.9,14.0])
Tobacco smoking in previous 6 months		
Did smoke tobacco cigarette	50/363 (13.8% [10.6,17.7])	284/3849 (7.4% [6.6,8.2])
Use e-cigarette in previous 6 months		
Did use e-cigarette	69/363 (19.0% [15.3,23.3])	602/3843 (15.7% [14.6,16.8])

[7] Due to higher missing responses on the discretionary food intake question among regional adolescents, a simple regression analysis of regional adolescents indicated no significant relationship between greater baseline risk for junk food scores and missing responses at 36-months (OR = 0.712, 95% CI: 0.389–1.329).

Appendix 1.8: Prevalence ratios with 95% confidence intervals (CI) for each risk behaviour among 4445 participants present at 36-month post-baseline follow-up in the Health4Life trial

	Prevalence Ratio	Lower 95% CI	Upper 95% CI
SSB consumption (more than 5 cups)			
*Not disadvantaged (ref) v Disadvantaged	1.17	0.90	1.52
Major city (ref) v Regional area	1.24	0.75	2.05
Mid to High SES (ref) v Low SES	1.24	0.94	1.64
Insufficient fruit intake (<2 servings of fruit/day)			
*Not disadvantaged (ref) v Disadvantaged	1.03	0.91	1.16
Major city (ref) v Regional area	0.88	0.70	1.11
Mid to High SES (ref) v Low SES	1.09	0.96	1.25
Insufficient vegetable intake (<5 servings of vegetables/day)			
*Not disadvantaged (ref) v Disadvantaged	0.98	0.96	1.01
Major city (ref) v Regional area	0.96	0.92	1.01
Mid to High SES (ref) v Low SES	0.99	0.97	1.02
Excessive discretionary food consumption (≥1/day)			
*Not disadvantaged (ref) v Disadvantaged	0.84	0.76	0.94
Major city (ref) v Regional area	0.88	0.74	1.04
Mid to High SES (ref) v Low SES	0.87	0.77	0.99
Consumed full standard alcoholic drink (in previous 6-months)			
*Not disadvantaged (ref) v Disadvantaged	0.84	0.71	1.00
Major city (ref) v Regional area	1.41	1.00	1.97
Mid to High SES (ref) v Low SES	0.78	0.65	0.93
Binge drank alcohol (in previous 6-months)			
*Not disadvantaged (ref) v Disadvantaged	0.76	0.58	1.01
Major city (ref) v Regional area	1.77	1.07	2.93
Mid to High SES (ref) v Low SES	0.68	0.50	0.92

Tobacco use (any use in previous 6-months)			
*Not disadvantaged (ref) v Disadvantaged	1.32	0.97	1.79
Major city (ref) v Regional area	2.06	1.18	3.60
Mid to High SES (ref) v Low SES	1.23	0.89	1.71
E-cigarette use (any use in previous 6-months)			
*Not disadvantaged (ref) v Disadvantaged	0.89	0.71	1.12
Major city (ref) v Regional area	1.24	0.83	1.87
Mid to High SES (ref) v Low SES	0.85	0.66	1.09

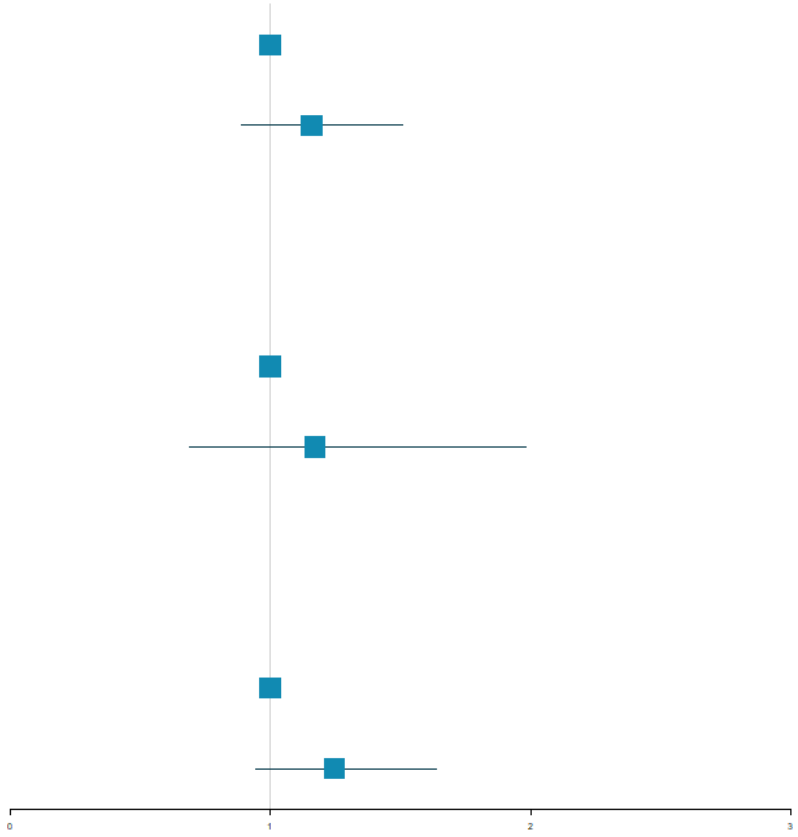
**Not disadvantaged versus disadvantaged were included in a separate model to comparing geographical location (major city v regional area) and socioeconomic status (mid to high v low SES) due to the overlap of the groupings.*

Note: Prevalence ratios with 95% CIs that did not cross 1 were considered significant.

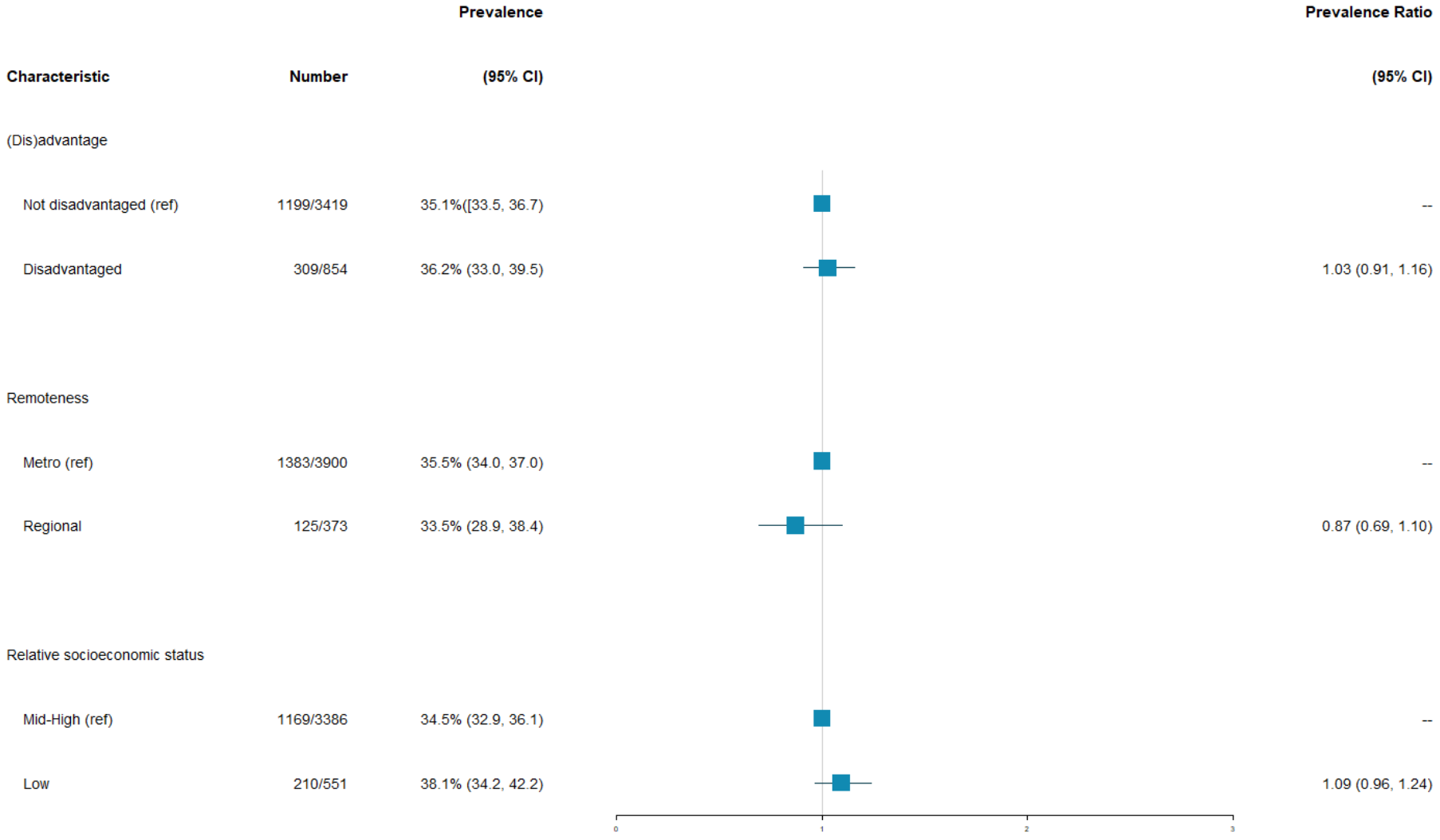
Forest plots for each primary outcome

Appendix 1.1: Excessive SSB consumption forest plot

Characteristic	Number	Prevalence (95% CI)	Prevalence Ratio (95% CI)
(Dis)advantage			
Not disadvantaged (ref)	332/3419	9.7% (8.8, 10.7)	--
Disadvantaged	112/853	13.1% (11.0, 15.6)	1.16 (0.89, 1.51)
Remoteness			
Metro (ref)	397/3899	10.2% (9.3, 11.2)	--
Regional	47/373	12.6% (9.6, 16.4)	1.17 (0.69, 1.98)
Relative socioeconomic status			
Mid-High (ref)	322/3386	9.5% (8.6, 10.5)	--
Low	76/550	13.8% (11.2, 17.0)	1.24 (0.95, 1.64)

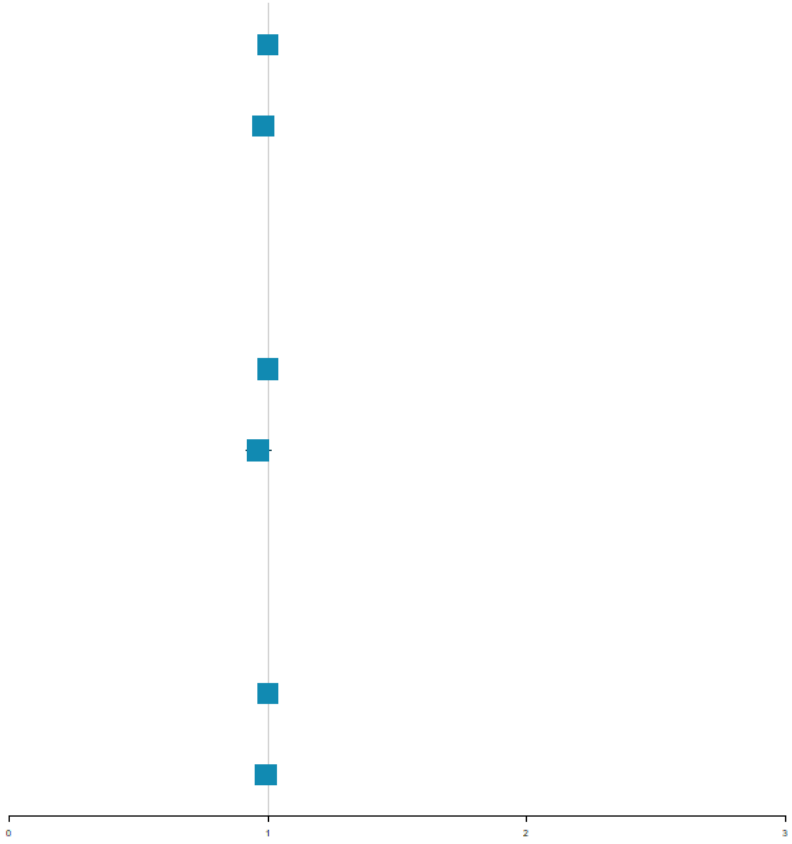


Appendix 1.2: Insufficient fruit intake forest plot

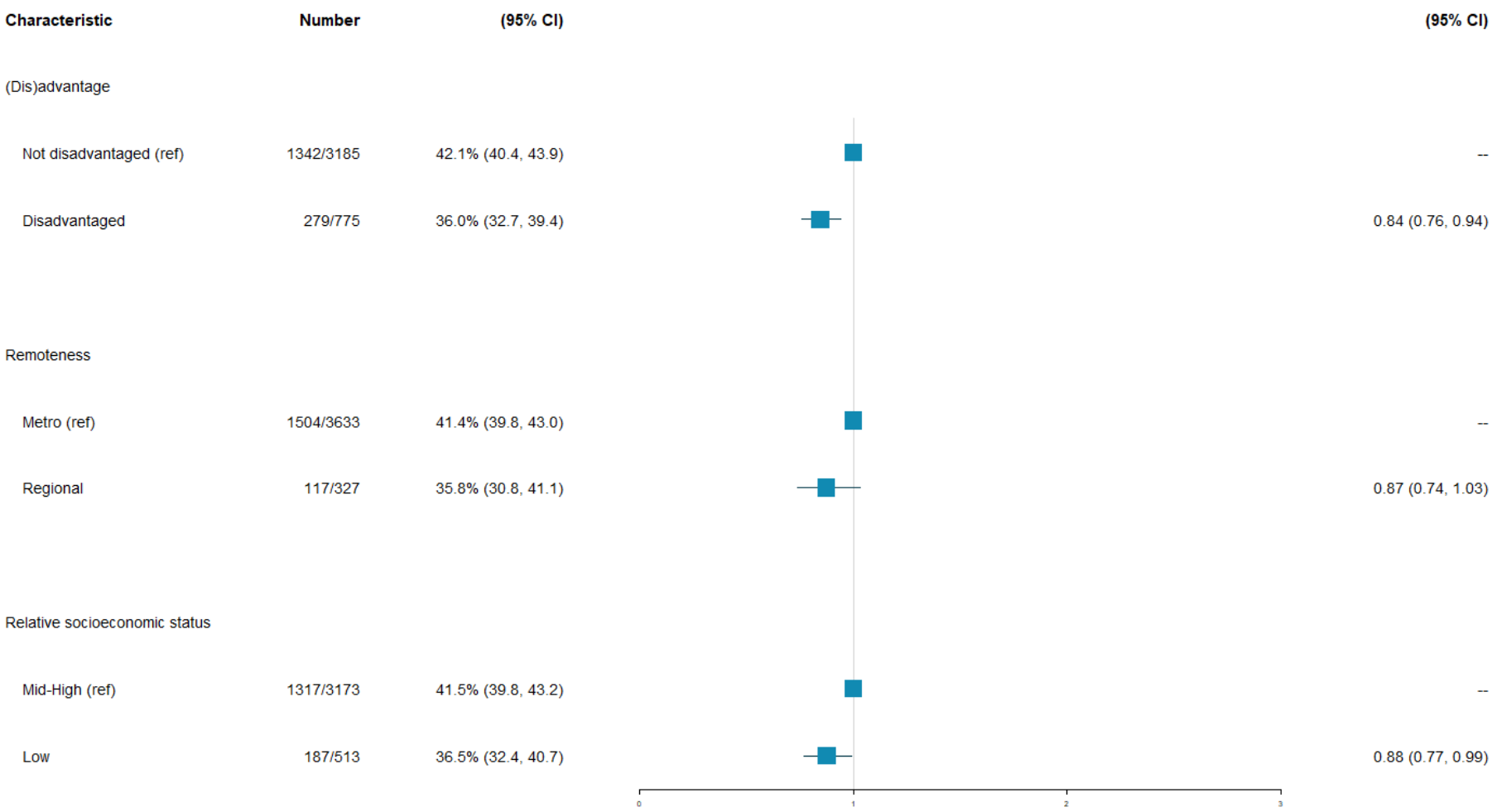


Appendix 1.3: Insufficient vegetable intake forest plot

Characteristic	Number	Prevalence (95% CI)	Prevalence Ratio (95% CI)
(Dis)advantage			
Not disadvantaged (ref)	2989/3419	87.4% (86.3, 88.5)	--
Disadvantaged	719/854	84.2% (81.6, 86.5)	0.98 (0.96, 1.01)
Remoteness			
Metro (ref)	3399/3900	87.2% (86.1, 88.2)	--
Regional	309/373	82.8% (78.7, 86.3)	0.96 (0.92, 1.01)
Relative socioeconomic status			
Mid-High (ref)	2952/3386	87.2% (86.0, 88.3)	--
Low	468/551	84.9% (81.7, 87.7)	0.99 (0.96, 1.02)

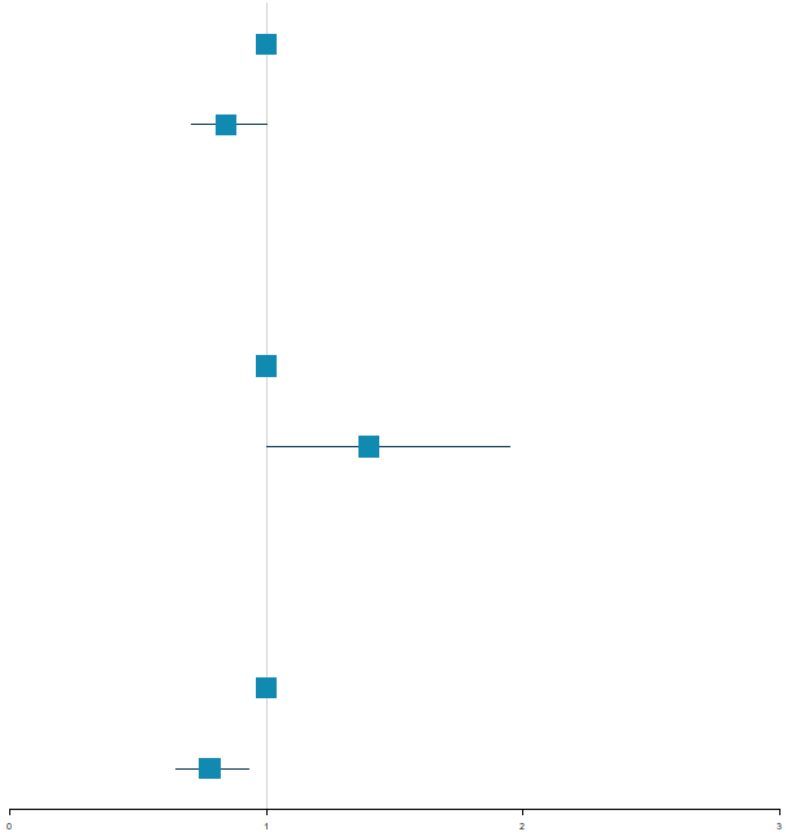


Appendix 1.4: Excessive discretionary food consumption forest plot

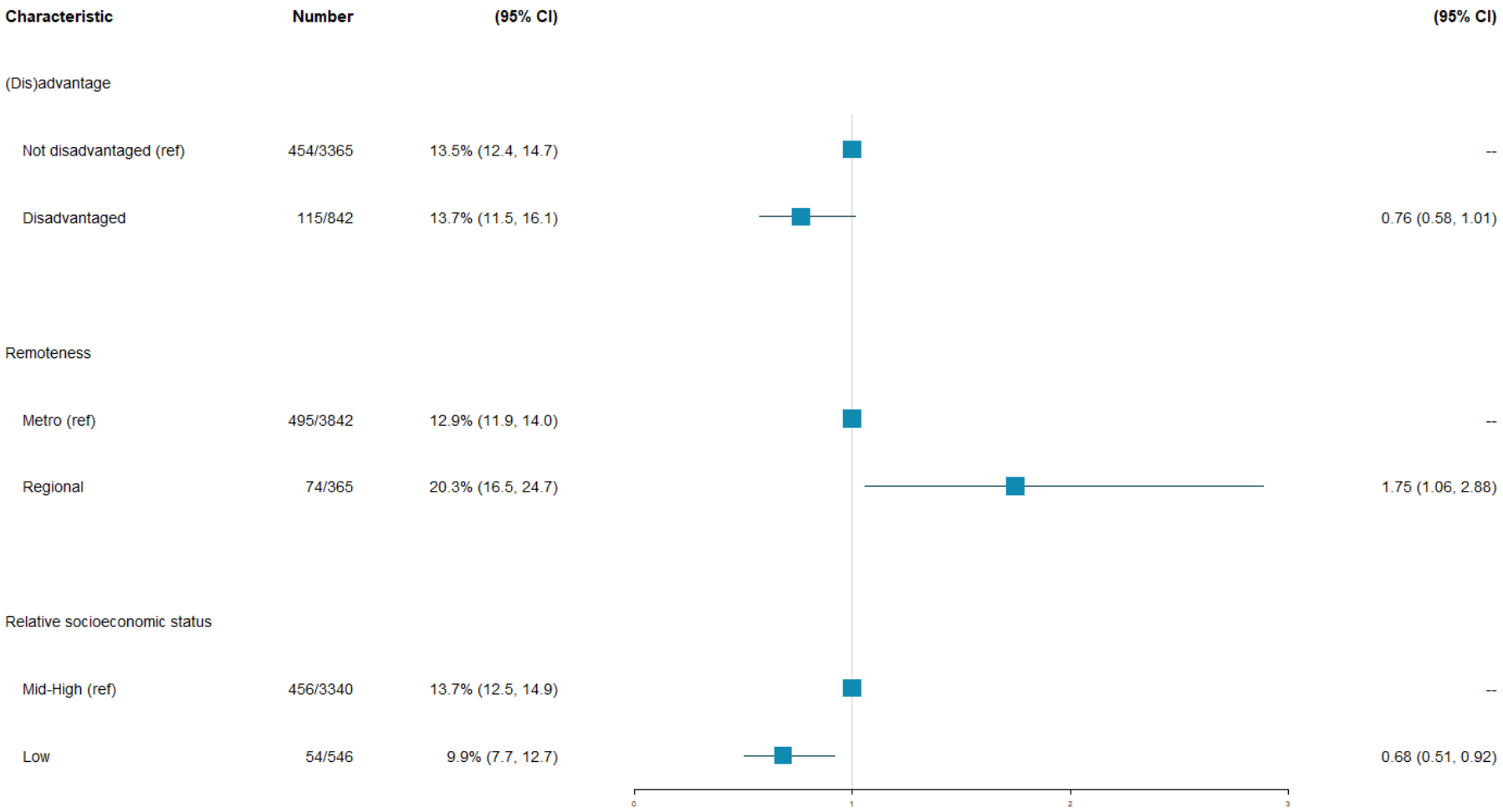


Appendix 1.5: Consumed full standard drink of alcohol in previous 6-months forest plot

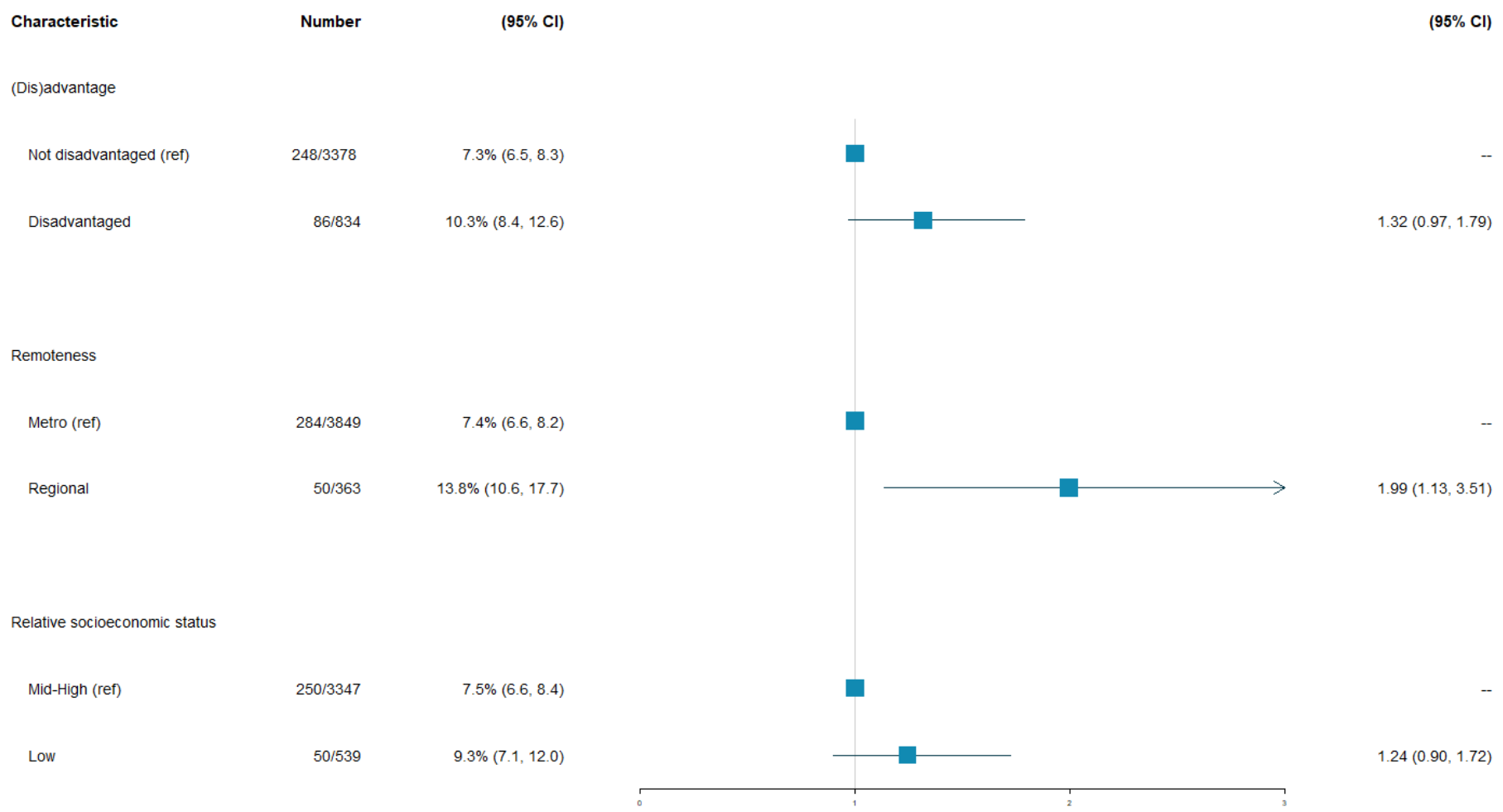
Characteristic	Number	Prevalence (95% CI)	Prevalence Ratio (95% CI)
(Dis)advantage			
Not disadvantaged (ref)	1012/3381	29.9% (28.4, 31.5)	--
Disadvantaged	251/844	29.7% (26.8, 32.9)	0.84 (0.71, 1.00)
Remoteness			
Metro (ref)	1122/3859	29.1% (27.7, 30.5)	--
Regional	141/366	38.5% (33.7, 43.6)	1.40 (1.00, 1.95)
Relative socioeconomic status			
Mid-High (ref)	1024/3355	30.5% (30.0, 32.1)	--
Low	135/547	24.7% (21.2, 28.5)	0.78 (0.65, 0.93)



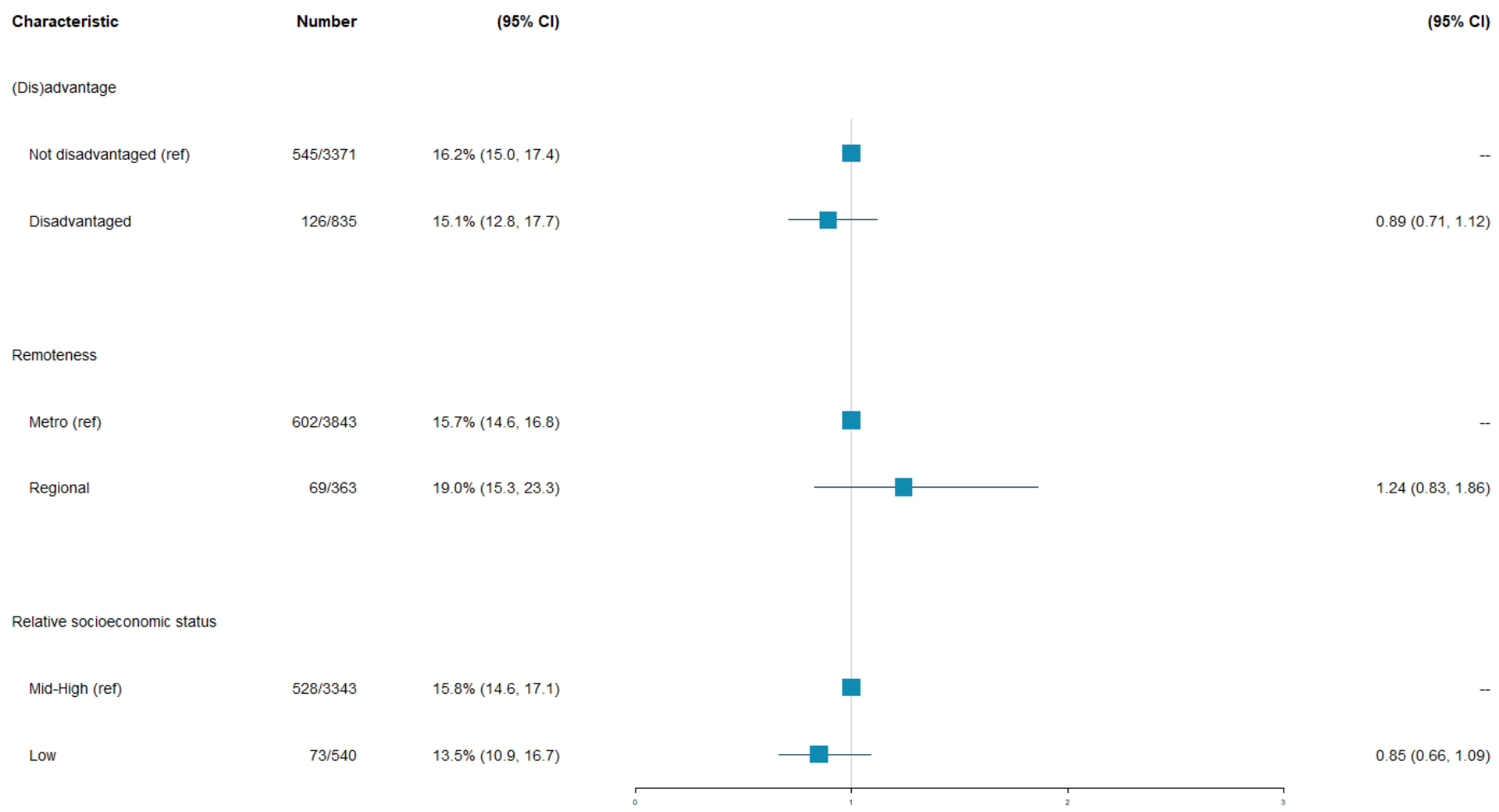
Appendix 1.6: Binge drank alcohol in previous 6-months forest plot



Appendix 1.7: Tobacco smoking in previous 6-months forest plot



Appendix 1.8: E-cigarette use in previous 6-months forest plot



Appendix 2

Supplementary materials for Chapter 3

Appendix 2.1: Example Search Strategy

Database(s): MEDLINE (Ovid) search strategy from 1946 to Present

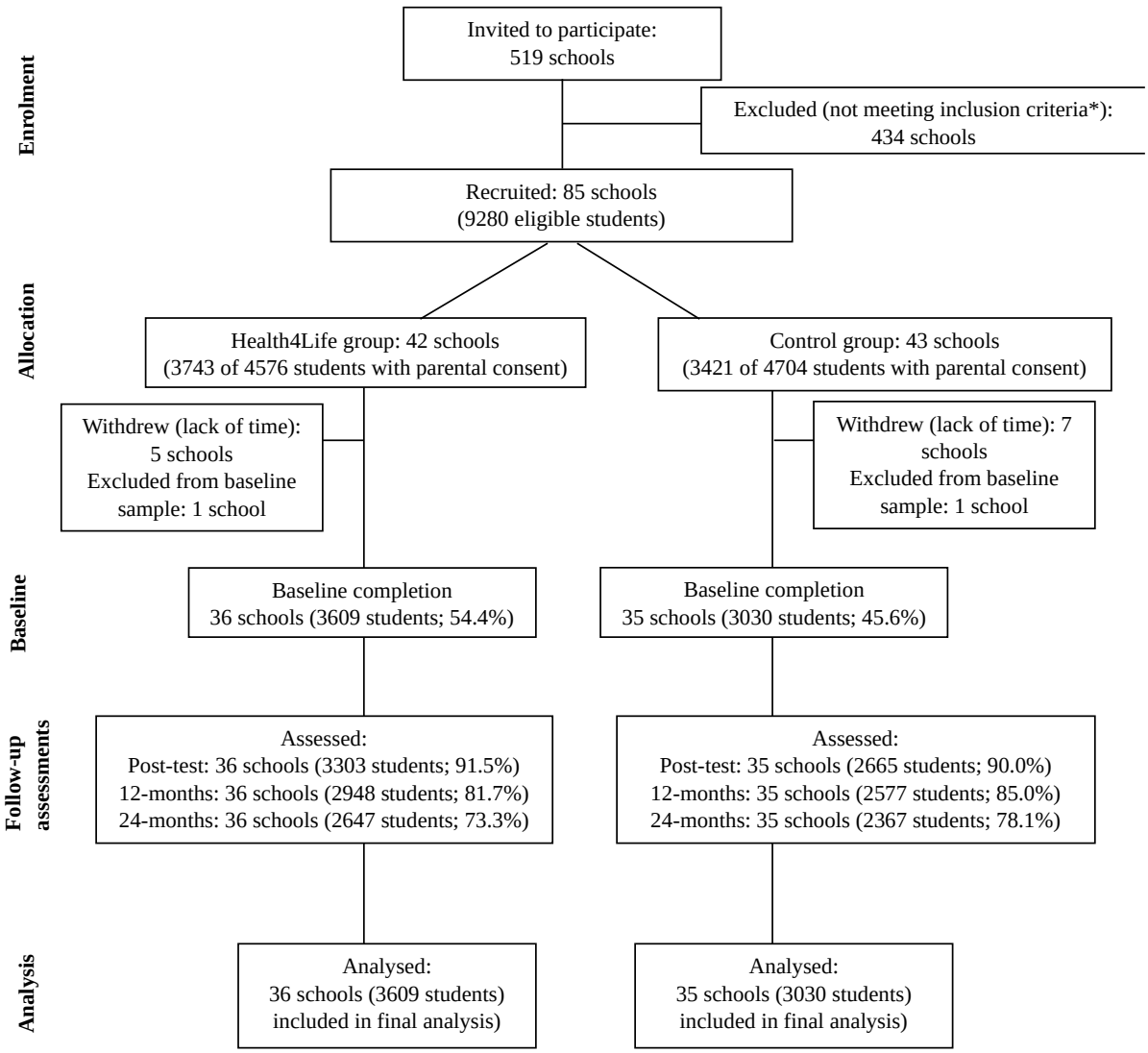
Search Strategy: December 19, 2022

Number	Search term
1	(ehealth or mhealth or electronic health or mobile health or telemedicine or telehealth).mp.
2	Telemedicine/
3	1 or 2
4	teen*.mp.
5	adolescen*.mp. or Adolescent/
6	child*.mp. or Child/
7	young adult*.mp. or Young Adult/
8	4 or 5 or 6 or 7
9	diet*.mp. or Diet/
10	nutrition.mp.
11	alcohol.mp.
12	Alcoholic Beverages/
13	smoking.mp. or Smoking/
14	cigarette.mp. or Tobacco Products/
15	vaping.mp. or Vaping/
16	9 or 10 or 11 or 12 or 13 or 14 or 15
17	socioeconomic status.mp. or Social Class/
18	Socioeconomic Factors/ or low socioeconomic.mp.
19	poor.mp. or Working Poor/
20	low income.mp.
21	rural.mp. or Rural Health/ or Rural Population/
22	(regional or remote).mp.
23	17 or 18 or 19 or 20 or 21 or 22
24	3 and 8 and 16 and 23

Appendix 3

Supplementary materials for Chapter 4

Appendix 3.1: Consolidated Standards of Reporting Trials (CONSORT) summary of participant flow through the Health4Life study (Champion et al., 2023)



*schools were excluded if they: (1) had fewer than 30 year 7 students; (2) relevant ethics approval was not obtained; and (3) were not located in Greater Sydney (NSW), regional areas of New South Wales, within a 100 km radius from Brisbane (QLD), or within a 600 km radius from Perth (WA).

Appendix 3.2: Measures – additional information

Sociodemographic factors

SES: Students provided self-reported information on gender, age, SES and geographical location. To assess SES, the Family Affluence Scale III was used as a proxy measure, which has been widely used and validated in previous studies (Currie et al., 2008; Torsheim et al., 2016). This scale enables a comparison of participants' SES relative to others within the sample. To generate a comprehensive representation of SES in this study, the scale was transformed into ridit scores ranging from 0 to 1. Higher ridit scores indicate higher relative SES. For the purpose of interpretation, the continuous ridit scores were further categorised into three groups based on the distribution of SES in the study population. These categories included a lower SES group (ridit < 0.2), a middle SES group (ridit ≥ 0.2 and ≤ 0.6), and an upper SES group (ridit > 0.6) (Elgar et al., 2017).

Geographical location: The geographical remoteness of the participants' schools was assessed using the nationally recognised Australian Statistical Geography Standard Remoteness Structure (Australian Bureau of Statistics, 2023). This classification system categorised schools into major city, inner regional, outer regional, remote, or very remote based on their geographical location. Given that many participants were unsure of their home postcode, the school's geographical remoteness classification was used as a substitute for each individual's geographical remoteness. Schools were then coded in this study as being either metropolitan or regional.

Primary outcomes

Diet: The Student Physical Activity and Nutrition Survey (SPANS) was used to measure consumption of SSBs, fruit, vegetable, and discretionary foods (junk food such as fried potato products, confectionary foods, and takeaway meals) (Hardy et al., 2016). To evaluate the overall risk associated with poor dietary patterns, a composite indicator of poor diet was calculated. Individuals who fulfilled the criteria for high sugar-sweetened beverage (SSB) consumption (5-6 cups/week or 1 or more cups/day of SSB) or met two or more of the following conditions were classified as having a poor diet: consuming fewer than two servings of fruit per day, consuming fewer than five servings of vegetables per day, or consuming more than one serving of discretionary food items per day. The cut-offs for fruit and vegetable intake were established according to the Australian Dietary Guidelines (National Health and Medical Research Council, 2013), while guidance from nutritionists and health recommendations were followed for SSB and discretionary food variables, as official guidelines were not available for these particular variables.

Alcohol: Alcohol consumption was evaluated using a single item measure designed to determine participants' consumption of a full standard drink over the previous six months, where participants were asked, "Have you had a full standard alcoholic drink in the past 6 months?" (0 = No, 1 = Yes). To facilitate participants' responses, they were shown a pictorial chart displaying the standard drink quantities of various types of alcoholic beverages and sizes.

Tobacco: Tobacco use was assessed using a single item measure from the Youth Risk Behaviour Survey, with participants asked, "In the past 6 months, have you tried cigarette smoking, even one or two puffs?" (0 = No, 1=Yes) (Brener et al., 2013).

Secondary outcomes

Knowledge: A 20-item scale was used to assess participants' knowledge of the content covered in the *Health4Life* study. This scale was specifically designed to evaluate awareness of chronic disease risk factors and covered important areas such as alcohol guidelines, dietary intake, physical activity, screen time, and sleep. Additionally, the scale encompassed knowledge of the prevalence of alcohol and tobacco use among young Australians, as well as the impact of the six lifestyle risk behaviours targeted in the intervention on both physical and mental health. The items were presented as "True", "False", "Don't Know" statements, and scores were totalled to produce an overall knowledge score.

Behavioural Intentions: Behavioural intentions to participate in or modify behaviours relating to alcohol use, tobacco smoking and poor diet were evaluated using a self-report questionnaire. Alcohol intentions were assessed using established measures (Newton et al., 2012), while items for tobacco and poor diet (specifically sugar-sweetened beverages such as energy drinks, soft drinks, sports drinks, or cordial) were adapted from these measures. Participants rated their likelihood of trying alcohol and tobacco in the future, with responses ranging from 0 (very unlikely) to 4 (very likely). For sugar-sweetened beverages, participants indicated their intention to replace energy drinks, soft drinks, sports drinks, or cordial with water on a scale from 0 (not at all true of me) to 3 (very true of me) on all or most days of the week for the next three months. For subsequent analysis in this study aimed at determining participants' intentions regarding alcohol use, tobacco smoking, and dietary habits, responses were converted into binary variables. For alcohol and tobacco questions, scores of 0-2 indicated no intention to engage in alcohol use or tobacco smoking, while scores of 3-4 indicated an intention to do so. Regarding SSBs, responses of 0-1 were recoded as no intention to replace SSB consumption with water, while responses of 2-3 indicated an intention to make the substitution.

Psychological Distress: Psychological distress was assessed using the widely used and validated measure for adolescents, the Kessler 6 (K6) scale, which measures the frequency of six symptoms of psychological distress experienced by individuals over the past four weeks (Furukawa et al., 2003; Mewton et al., 2016). These symptoms include feeling nervous, hopeless, or restless, and others. Participants were asked to rate each symptom on a 5-point Likert scale ranging from "none of the time" to "all of the time". Scores from the K6 are totalled to create a composite score, with higher scores indicating greater psychological distress.

Statistical Analyses: Description of Model Types

Latent growth curve models (LGMs) in Mplus (v 8.4. (Muthén & Muthén, 2017)) were used to evaluate the moderating effects of SES and geographical location on primary and secondary outcomes over 24-month post baseline assessments. LGMs are part of the broader structural equation modelling framework that allow for estimating changes in measured variables over time by modelling them as latent variables that are expected to vary over time. A set of growth parameters are included in the model, such as the intercept and slope, which

indicate the starting level of the variable at the beginning of the study and the rate of change in the variable over time, respectively. To determine the moderation effect of SES and geographical location on the intervention effectiveness, the relationship between each of these variables and the slope latent factor was examined, yielding an estimation of the difference in the change in outcome over time between varying levels of SES and geographical location. When significant moderation effects were reported ($p<0.05$), we conducted subset analyses to determine the difference in intervention effects by group, by comparing the varying levels of SES (three levels; 1 = low, 2 = mid, 3 = high) and geographical location (two levels; 0 = metropolitan, 1 = regional) on outcomes.

Logistic latent growth models: For the binary variables (poor diet, alcohol and tobacco use, and behavioural intentions) the growth models employed a log odds function to estimate the relationship. The intervention effect sizes, including odds ratios and corresponding 95% CIs were estimated by exponentiating new parameter variables in R Studio. The intervention effect was estimated over a one-year period for the linear models (poor diet, behavioural intentions) and over a 24-month period for the free model (alcohol and tobacco use), during the trial.

Continuous latent growth models: For continuous variables (knowledge and psychological distress), the models estimated a mean change and standard error in scores (referred to as the slope parameters). The slope parameters varied depending on the type of model employed, with free applied to knowledge and linear applied to psychological distress. These parameters measured the extent of change in the predicted outcome over a one-year period for the linear model and a 24-month period for the free model, during the trial.

Statistical Analyses: Model Fit

We tested various model specifications, including linear, quadratic, and freely estimated, on unconditional LGMs to determine the optimal time structure and slope estimates for each outcome. Model selection depended on model fit statistics, including Akaike information criterion (AIC), Bayesian information criterion (BIC), and sample-size adjusted BIC. Based on these statistics, models were either linear estimated time scores (representing average 12-month change) or free (representing average 24-month change). Refer to Appendix 3.3 for detailed model fit statistics.

Appendix 3.3: Model fit statistics for the best fitting unconditional growth models

Variable	Model	χ2	df	p-value	AIC	BIC	SSABIC	RMSEA	CFI	TLI
Poor diet	Linear	8.611	10	0.5694	5067.551	5093.839	5077.956			
Alcohol use in the past 6 months	Free	4.695	8	0.7897	9309.035	9356.581	9334.336			
Tobacco use in the past 6 months	Free	7.877	7	0.4456	5323.383	5370.918	5348.674			
Diet intentions	Linear	36.412	10	<0.01	25964.77	25998.72	25982.83			
Alcohol intentions	Linear	20.929	10	0.0216	24477.253	24511.206	24495.317			
Tobacco intentions	Linear	14.648	10	0.1454	7062.347	7096.298	7080.409			
Knowledge	Free	241.727	5	<.001	115135.666	115196.86	115168.26	0.085 (95% CI 0.076, 0.094)	0.960	0.952
Psychological distress symptoms over the past four weeks K6 scale	Linear	55.403	5	<0.01	131651.039	131712.153	131683.553	0.039 (95% CI 0.030, 0.049)	0.981	0.977

Appendix 3.4: Summary of raw number of participants and prevalence (95% confidence interval) for each categorical outcome by time, intervention status and participant characteristics

Outcomes	Number and prevalence (95% CI)			
	Baseline	**Post-intervention follow-up**	**12-month follow-up**	**24-month follow-up**
Poor diet				
Low SES				
Health4Life	**293/542** 54.1% (49.8-58.2)	**196/398** 49.2% (44.4-54.1)	**202/378** 53.4% (48.4-58.4)	**197/344** 57.3% (52.0-62.4)
Control	**155/316** 49.1% (43.6-54.5)	**118/270** 43.7% (37.9-49.7)	**134/267** 50.2% (44.2-56.1)	**135/256** 52.7% (46.6-58.8)
Mid SES				
Health4Life	**632/1156** 54.7% (51.8-57.5)	**442/940** 47.0% (43.8-50.2)	**448/860** 52.1% (48.8-55.4)	**458/802** 57.1% (53.7-60.5)
Control	**441/929** 47.5% (44.3-50.7)	**382/803** 47.6% (44.1-51.0)	**398/789** 50.4% (47.0-53.9)	**376/738** 50.9% (47.3-54.5)
High SES				
Health4Life	**735/1504** 48.9% (46.3-51.4)	**536/1215** 44.1% (41.3-46.9)	**588/1181** 49.8% (46.9-52.6)	**556/1012** 54.9% (51.9-58.0)
Control	**561/1211** 46.3% (43.5-49.1)	**487/1108** 44.0% (41.1-46.9)	**493/1031** 47.8% (44.8-50.9)	**501/968** 51.8% (48.6-54.9)
Metropolitan				
Health4Life	**1595/3039** 52.5% (50.7-54.3)	**1187/2561** 46.3% (44.4-48.3)	**1217/2366** 51.4% (49.4-53.4)	**1197/2133** 56.1% (54.0-58.2)
Control	**1078/2209** 48.8% (46.7-50.9)	**990/2096** 47.2% (45.1-49.4)	**1035/2017** 51.3% (49.1-53.5)	**1034/1939** 53.3% (51.1-55.5)
Regional				
Health4Life	**119/245** 48.6% (42.4-54.8)	**75/155** 48.4% (40.7-56.2)	**108/190** 56.8% (49.7-63.7)	**95/157** 60.5% (52.7-67.8)
Control	**128/321** 39.9% (34.7-45.3)	**100/270** 37.0% (31.5-42.9)	**102/280** 36.4% (31.0-42.2)	**96/227** 42.3% (36.0-48.8)
Alcohol use in the past 6 months				
Low SES				
Health4Life	**31/558** 5.6% (3.9-7.8)	**14/421** 3.3% (2.0-5.5)	**50/425** 11.8% (9.0-15.2)	**62/370** 16.8% (13.3-20.9)
Control	**10/351** 2.8% (1.6-5.2)	**16/286** 5.6% (3.5-8.9)	**22/280** 7.9% (5.2-11.6)	**33/264** 12.5% (9.0-17.0)
Mid SES				
Health4Life	**26/1202**	**18/984**	**68/943**	**148/854**

	2.2% (1.5-3.2)	1.8% (1.2-2.9)	7.2% (5.7-9.0)	17.3% (14.9-20.0)
Control	**23/1003**	**33/830**	**58/844**	**115/775**
	2.3% (1.5-3.4)	4.0% (2.8-5.5)	6.9% (5.4-8.8)	14.8% (12.5-17.5)
High SES				
Health4Life	**46/1559**	**47/1270**	**99/1263**	**178/1068**
	3.0% (2.2-3.9)	3.7% (2.8-4.9)	7.8% (6.5-9.5)	16.7% (14.5-19.0)
Control	**31/1336**	**41/1150**	**94/1115**	**158/1007**
	2.3% (1.6-3.3)	3.6% (2.6-4.8)	8.4% (6.9-10.2)	15.7% (13.6-18.1)
Metropolitan				
Health4Life	**86/3203**	**75/2683**	**194/2590**	**352/2264**
	2.7% (2.2-3.3)	3.0% (2.2-3.5)	7.5% (6.5-8.6)	15.5% (14.1-17.1)
Control	**59/2520**	**82/2195**	**167/2171**	**301/2009**
	2.3% (1.8-3.0)	3.7% (3.0-4.6)	7.7% (6.6-8.9)	15.0% (13.5-16.6)
Regional				
Health4Life	**24/263**	**9/163**	**37/214**	**56/174**
	9.1% (6.2-13.2)	5.5% (2.9-10.2)	17.3% (12.8-22.9)	32.2% (25.7-39.4)
Control	**12/359**	**16/282**	**23/309**	**41/255**
	3.3% (1.9-5.8)	5.7% (3.5-9.0)	7.4% (5.0-10.9)	16.1% (12.1-21.1)
Tobacco use in the past 6 months				
Low SES				
Health4Life	**16/558**	**14/419**	**19/422**	**30/369**
	2.9% (1.8-4.6)	3.3% (2.0-5.5)	4.5% (2.9-6.9)	8.1% (5.8-11.4)
Control	**15/349**	**10/286**	**11/280**	**14/265**
	4.3% (2.6-7.0)	3.5% (1.9-6.3)	3.9% (2.2-6.9)	5.3% (3.2-8.7)
Mid SES				
Health4Life	**15/1200**	**21/980**	**42/934**	**58/852**
	1.3% (0.8-2.1)	2.1% (1.4-3.3)	4.5% (3.3-6.0)	6.8% (5.3-8.7)
Control	**19/1002**	**15/833**	**29/842**	**34/774**
	1.9% (1.2-2.9)	1.8% (1.1-2.9)	3.4% (2.4-4.9)	4.4% (3.2-6.1)
High SES				
Health4Life	**19/1560**	**19/1269**	**43/1259**	**70/1059**
	1.2% (0.8-1.9)	1.5% (0.9-2.3)	3.4% (2.5-4.6)	6.6% (5.3-8.3)
Control	**7/1333**	**18/1146**	**48/1112**	**62/1002**
	0.5% (0.3-1.1)	1.6% (0.9-2.5)	4.3% (3.3-5.7)	6.2% (4.9-7.9)
Metropolitan				
Health4Life	**45/2192**	**46/2674**	**92/2573**	**134/2250**
	1.4% (1.1-1.9)	1.7% (1.3-2.3)	3.6% (2.9-4.4)	6.0% (5.1-7.0)
Control	**38/2495**	**41/2191**	**84/2162**	**109/2005**
	1.5% (1.1-2.1)	1.9% (1.4-2.5)	3.9% (3.1-4.8)	5.4% (4.5-6.5)

Regional				
Health4Life	**9/260**	**6/162**	**16/208**	**30/173**
	3.5% (1.8-6.4)	3.7% (1.7-7.8)	7.7% (4.8-12.1)	17.3% (12.4-23.7)
Control	**5/358**	**7/282**	**11/308**	**12/253**
	1.4% (0.6-3.2)	2.5% (1.2-5.0)	3.6% (2.0-6.3)	4.7% (2.7-8.1)
Diet intentions				
Low SES				
Health4Life	**348/556**	**283/415**	**262/415**	**256/367**
	62.6% (58.5-66.5)	68.2% (63.6-72.5)	63.1% (58.4-67.6)	69.8% (64.9-74.2)
Control	**219/346**	**193/284**	**170/276**	**193/259**
	63.3% (58.1-68.2)	68.0% (62.3-73.1)	61.6% (55.7-67.1)	74.5% (68.9-79.4)
Mid SES				
Health4Life	**754/1194**	**690/972**	**630/930**	**593/839**
	63.1% (60.4-65.8)	71.0% (68.1-73.8)	67.7% (64.7-70.6)	70.7% (67.5-73.7)
Control	**666/1001**	**590/828**	**547/835**	**524/770**
	66.5% (63.6-69.4)	71.3% (68.1-74.2)	65.5% (62.2-68.7)	68.1% (64.7-71.2)
High SES				
Health4Life	**979/1553**	**887/1256**	**826/1247**	**745/1052**
	63.0% (60.1-65.4)	70.6% (68.0-73.1)	66.2% (63.6-68.8)	70.8% (68.0-73.4)
Control	**848/1328**	**788/1145**	**725/1105**	**674/994**
	63.9% (61.2-66.4)	68.8% (66.1-71.4)	65.6% (62.8-68.4)	67.8% (64.8-70.6)
Metropolitan				
Health4Life	**1986/3169**	**1858/2651**	**1680/2552**	**1579/2228**
	62.7% (61.0-64.3)	70.1% (68.3-71.8)	65.8% (64.0-67.6)	70.9% (68.9-72.7)
Control	**1590/2476**	**1500/2182**	**1385/2145**	**1342/1983**
	64.2% (62.3-66.1)	68.7% (66.8-70.7)	64.6% (62.5-66.6)	67.7% (65.6-69.7)
Regional				
Health4Life	**158/259**	**106/161**	**126/204**	**103/170**
	61.0% (54.9-66.7)	65.8% (58.2-72.7)	61.8% (54.9-68.2)	60.6% (53.1-67.6)
Control	**241/357**	**198/279**	**198/303**	**176/251**
	67.5% (62.5-72.2)	71.0% (65.4-76.0)	65.3% (59.8-70.5)	70.1% (64.2-75.4)
Alcohol intentions				
Low SES				
Health4Life	**174/554**	**128/415**	**162/414**	**173/369**
	31.4% (27.7-35.4)	30.8% (26.6-35.4)	39.1% (34.5-43.9)	46.9% (41.9-52.0)
Control	**110/346**	**104/285**	**128/279**	**136/266**
	31.8% (27.1-36.9)	36.5% (31.1-42.2)	45.9% (40.1-51.7)	51.1% (45.1-57.1)
Mid SES				
Health4Life	**442/1200**	**356/974**	**464/932**	**464/849**
	36.8% (34.2-39.6)	36.6% (33.6-39.6)	49.8% (46.6-53.0)	54.7% (51.3-58.0)

Control	**407/1001**	**386/828**	**447/838**	**452/771**
	40.7% (37.7-43.7)	46.6% (43.2-50.0)	53.3% (50.0-56.7)	58.6% (55.1-62.1)
High SES				
Health4Life	**614/1555**	**489/1262**	**639/1257**	**573/1051**
	39.5% (37.1-41.9)	38.7% (36.1-41.5)	50.8% (48.1-53.6)	54.5% (51.5-57.5)
Control	**548/1334**	**491/1141**	**593/1109**	**608/997**
	41.1% (38.5-43.7)	43.0% (40.2-45.9)	53.5% (50.5-56.4)	61.0% (57.9-64.0)
Metropolitan				
Health4Life	**1150/3183**	**951/2658**	**1219/2562**	**1183/2240**
	36.1% (34.5-37.8)	35.8% (34.0-37.6)	47.6% (45.7-49.5)	52.8% (50.7-54.9)
Control	**965/2492**	**929/2178**	**1103/2154**	**1155/1995**
	38.7% (36.8-40.7)	42.7% (40.6-44.7)	51.2% (49.1-53.3)	57.9% (55.7-60.0)
Regional				
Health4Life	**125/261**	**71/162**	**115/207**	**99/172**
	47.9% (41.9-53.9)	43.8% (36.4-51.5)	55.6% (48.7-62.2)	57.6% (50.1-64.7)
Control	**167/357**	**132/281**	**178/306**	**159/252**
	46.8% (41.7-52.0)	47.0% (41.2-52.8)	58.2% (52.6-63.6)	63.1% (57.0-68.8)
Tobacco intentions				
Low SES				
Health4Life	**14/552**	**13/414**	**24/416**	**37/369**
	2.5% (1.5-4.2)	3.1% (1.8-5.3)	5.8% (3.9-8.4)	10.0% (7.4-13.5)
Control	**8/346**	**10/283**	**21/279**	**18/263**
	2.3% (1.2-4.5)	3.5% (1.9-6.4)	7.5% (5.0-11.2)	6.8% (4.4-10.6)
Mid SES				
Health4Life	**27/1992**	**31/975**	**58/931**	**64/845**
	2.3% (1.6-3.3)	3.2% (2.2-4.5)	6.2% (4.8-8.0)	7.6% (6.0-9.6)
Control	**27/992**	**28/828**	**41/837**	**54/771**
	2.7% (1.9-3.9)	2.4% (2.3-4.8)	4.9% (3.6-6.6)	7.0% (5.4-9.0)
High SES				
Health4Life	**33/1548**	**29/1259**	**67/1250**	**91/1051**
	2.1% (1.5-3.0)	2.3% (1.6-3.3)	5.4% (4.2-6.6)	8.6% (7.1-10.5)
Control	**24/1331**	**32/1142**	**69/1105**	**80/994**
	1.8% (1.2-2.7)	2.8% (2.0-3.9)	6.2% (5.0-7.8)	8.0% (6.5-9.9)
Metropolitan				
Health4Life	**65/3168**	**74/2653**	**137/2556**	**176/2236**
	2.1% (1.6-2.6)	2.8% (2.2-3.5)	5.4% (4.6-6.3)	7.9% (6.8-9.1)
Control	**51/2481**	**72/2177**	**130/2149**	**155/1990**
	2.1% (1.6-2.7)	3.3% (2.6-4.1)	6.0% (5.1-7.1)	7.8% (6.7-9.0)
Regional				
Health4Life	**12/258**	**8/162**	**18/207**	**27/171**

Control	4.7% (2.7-8.0) **11/356** 3.1% (1.7-5.4)	4.9% (2.5-9.4) **9/280** 3.2% (1.7-6.0)	8.7% (5.6-13.3) **20/306** 6.5% (4.3-9.9)	15.8% (11.1-22.0) **15/251** 6.0% (3.7-9.6)

Appendix 3.5: Summary of raw data for each continuous outcome by time, intervention status and participant characteristics

	Mean (95% confidence interval)			
Outcome	**Baseline**	**Post-intervention follow-up**	**12-month follow-up**	**24-month follow-up**
Knowledge				
Low SES				
Health4Life	11.4 (11.17-11.71)	13.3 (12.91-13.74)	12.4 (11.99-12.72)	12.4 (12.00-12.81)
Control	11.9 (11.62-12.24)	12.0 (11.57-12.37)	12.3 (11.93-12.62)	12.2 (11.82-12.66)
Mid SES				
Health4Life	12.0 (11.83-12.17)	14.3 (14.08-14.51)	13.2 (13.03-13.47)	13.3 (13.05-13.49)
Control	12.4 (12.25-12.62)	12.7 (12.49-12.93)	13.0 (12.75-13.15)	12.7 (12.51-12.97)
High SES				
Health4Life	12.0 (11.90-12.20)	14.3 (14.15-14.54)	13.3 (13.07-13.46)	13.3 (13.05-13.46)
Control	12.4 (12.26-12.57)	12.7 (12.53-12.90)	12.5 (12.34-12.73)	12.6 (12.37-12.80)
Metropolitan				
Health4Life	11.9 (11.78-11.99)	14.1 (13.99-14.27)	13.1 (12.97-13.24)	13.1 (12.93-13.22)
Control	12.1 (12.01-12.25)	12.5 (12.32-12.60)	12.5 (12.33-12.60)	12.5 (12.32-12.63)
Regional				
Health4Life	12.0 (11.67-12.42)	13.7 (13.15-14.28)	12.5 (12.02-12.96)	12.6 (12.07-13.06)
Control	13.1 (12.77-13.33)	13.2 (12.80-13.52)	13.4 (13.04-13.67)	12.9 (12.55-13.26)
Psychological Distress				
Low SES				
Health4Life	7.3 (6.82-7.77)	7.0 (6.37-7.54)	8.3 (7.66-8.99)	8.2 (7.49-8.85)
Control	7.6 (6.97-8.19)	7.1 (6.39-7.79)	7.9 (7.11-8.64)	8.0 (7.27-8.82)
Mid SES				
Health4Life	6.8 (6.49-7.11)	6.2 (5.79-6.53)	7.3 (6.89-7.68)	7.7 (7.27-8.12)
Control	6.9 (6.59-7.24)	6.6 (6.18-6.96)	7.8 (7.41-8.25)	8.4 (8.00-8.87)
High SES				
Health4Life	6.5 (6.29-6.81)	6.2 (5.86-6.50)	7.4 (7.06-7.75)	8.1 (7.67-8.43)
Control	6.7 (6.45-7.01)	6.6 (6.28-6.91)	7.9 (7.57-8.31)	8.2 (7.79-8.55)
Metropolitan				
Health4Life	6.8 (6.62-7.00)	6.3 (6.11-6.56)	7.5 (7.25-7.73)	7.9 (7.67-8.20)
Control	7.0 (6.79-7.21)	6.8 (6.57-7.05)	8.1 (7.82-8.35)	8.3 (7.99-8.53)
Regional				
Health4Life	6.8 (6.17-7.45)	6.6 (5.66-7.62)	7.8 (6.90-8.65)	7.8 (6.81-8.78)
Control	6.4 (5.89-6.95)	6.0 (5.30-6.64)	6.6 (5.98-7.30)	7.8 (7.02-8.50)

Appendix 3.6: Geographical location subgroup analyses on moderating the odds of diet-related outcomes.

Outcome	Location	Intercept		Slope	
		OR (CI)	p	OR (95% CI)	p
Poor diet	Metropolitan	1.08 (0.83-1.42)	0.565	0.99 (0.86-1.14)	0.915
	Regional	1.15 (0.51-2.61)	0.733	1.61 (1.13-2.29)	0.008
Diet intentions	Metropolitan	0.98 (0.81-1.19)	0.866	1.13 (1.01-1.27)	0.041
	Regional	1.77 (0.53-0.97)	0.030	0.97 (0.72-1.32)	0.857

Appendix 4

Supplementary materials for Chapter 5

Appendix 4.1: School Characteristics

Characteristic	
State (N(%))	
New South Wales	5 (83.3%)
Western Australia	1 (16.7%)
School ICSEA quartile (N(%))	
First	3 (50.0%)
Second-Fourth	3 (50.0%)
Geographic remoteness	
Inner or outer regional	4 (66.7%)
Major city	2 (33.3%)
School sector	
Government	5 (83.3%)
Independent	1 (16.7%)

Appendix 4.2: Overview of Health4Life module content

Lesson	Content
1	• Guidelines for eating healthily and benefits of a healthy diet. • Sleep needs for adolescents and benefits of sleeping well. • Guidelines for recreational screen time and benefits of limiting screen use.
2	• Reasons why young people choose to, or not to, drink alcohol/smoke. • Reducing harms from alcohol use and smoking. • Strategies to resist peer pressure. • Benefits of physical activity.
3	• Short and long-term consequences of alcohol and tobacco use. • Consequences of excessive sedentary recreational screen time. • Strategies to reduce sedentary recreational screen time. • Responsible use of social media.
4	• Social, financial and legal consequences of alcohol and tobacco use. • Assertive communication and refusal skills. • Guidelines for physical activity and sedentary behaviour. • SMART goal setting.
5	• Understanding food labels and serving sizes. • Limiting sugar-sweetened beverage consumption. • Improving sleep hygiene. • Benefits of sleeping well and prioritising sleep when needed.
6	• Associations and interrelations between health habits. • Relationships between the Big 6 and mental health. • Physical, social and emotional benefits of health and wellbeing. • The ‘Big 6’ and long-term health.

Appendix 4.3: Health4Life Student Evaluation Survey

Health4Life | Physical and mental wellbeing in adolescence and beyond

Health4Life Program – Online Student Evaluation

Thank you for completing the *Health4Life program*. We would now like to get your feedback about the program. Please answer the questions below.

The questions below refer to the online cartoon lessons

1. Overall, how would you rate the Health4Life program?

☐ Very Good
☐ Good
☐ Average
☐ Poor
☐ Very Poor

2. How much did you like learning in this way (i.e. via online cartoon lessons)?

☐ Liked a lot
☐ Liked a little
☐ Neither liked nor disliked
☐ Disliked a little
☐ Disliked a lot

3. How much did you like the stories in the Health4Life lessons?

☐ Liked a lot
☐ Liked a little
☐ Neither liked nor disliked
☐ Disliked a little
☐ Disliked a lot

4. How relevant were the stories to experiences in your own life?

☐ Completely relevant
☐ Somewhat relevant
☐ Unsure
☐ Somewhat irrelevant
☐ Completely irrelevant

5. How helpful was the information to you?

☐ Extremely helpful

☐ Somewhat helpful
☐ Neither helpful or unhelpful
☐ Somewhat unhelpful
☐ Extremely unhelpful

6. Do you think the skills and information you received in the program will help you to be healthy in the future?

☐ Yes, I think they will help a great deal
☐ Yes, I think they will help somewhat
☐ No, I don't think they will help at all
☐ I'm not sure whether they will help or not

7. How likely are you to use the skills and information taught in the program in your own life?

☐ Very Likely ☐ Likely ☐ Unsure ☐ Unlikely ☐ Very Unlikely

8. Would you recommend the Health4Life program to your friends?

☐ Yes ☐ No ☐ Maybe

9. Please list <u>ONE good thing</u> about the Health4Life program:

_____

_____

_____

10. Please list <u>ONE bad thing</u> about the Health4Life program:

_____

_____

_____

Appendix 4.4: Health4Life Teacher Evaluation Survey

Health4Life | Physical and mental wellbeing in adolescence and beyond

Health4Life Program - Teacher Evaluation

Thank you for completing the *Health4Life program*. We would now like to get your feedback about the program. Please answer the questions below.

1. Overall, how would you rate the Health4Life program?

☐ Very good
☐ Good
☐ Average
☐ Poor
☐ Very poor

2. How would you rate the Health4Life program in comparison to other school-based health education programs?

☐ Much better than most programs
☐ Better than most programs
☐ The same as most programs
☐ Worse than most programs.
☐ A lot worse than most programs

3. How easy did you find it to implement the Internet-based component of Health4Life program?

☐ Very easy
☐ Easy
☐ Average
☐ Difficult
☐ Very difficult

4. How easy was it for you to gain access to the computer facilities at your school for the Health and Physical Education classes?

☐ Very easy
☐ Easy
☐ Average
☐ Difficult
☐ Very difficult

5. How well do you think the cartoon stories held the students' attention?

- ☐ Very well
- ☐ Well
- ☐ Average
- ☐ Poorly
- ☐ Very poorly

6. How well do you think the students could recall the health information after the cartoon-based stories?

- ☐ Very well
- ☐ Well
- ☐ Average
- ☐ Poorly
- ☐ Very poorly

7. How much do you think the students liked the cartoon-based stories?

- ☐ Liked a lot
- ☐ Liked a little
- ☐ Average
- ☐ Disliked a little
- ☐ Disliked a lot

8. How would you rate the educational quality of the additional classroom activities included in the online Teacher Centre?

- ☐ Very good
- ☐ Good
- ☐ Average
- ☐ Poor
- ☐ Very poor

9. How easy did you find it to use the online Teacher Centre to prepare the activities for your class lessons?

- ☐ Very easy
- ☐ Easy
- ☐ Average
- ☐ Difficult
- ☐ Very difficult

10. How well do you believe the additional classroom activities helped to reinforce the health information to students?

- ☐ Very well

- ☐ Well
- ☐ Average
- ☐ Poorly
- ☐ Very poorly

11. How likely would you be to use the Health4Life course as a teaching resource in the future?

- ☐ Very likely
- ☐ Likely
- ☐ Undecided
- ☐ Unlikely
- ☐ Very unlikely

12. How likely is it that you would recommend the Health4Life course to others?

- ☐ Very likely
- ☐ Likely
- ☐ Undecided
- ☐ Unlikely
- ☐ Very unlikely

13. Could you please list any ways in which you think the Health4Life program could be improved for the future?

_____

_____

_____

_____

14. Please list any additional comments you have regarding the Health4Life modules

_____

_____

_____

_____

Appendix 4.5: Health4Life Teacher logbook survey (implementation data)

Health4Life | Physical and mental wellbeing in adolescence and beyond

TEACHER LOG BOOK

Teacher Name: _____ **School:** _____

[redacted]

MODULE 1	**Yes**	**No**
Did your students complete the online *Health4Life* cartoon component for Module 1?	☐	☐
Did your students complete the ***whole* online cartoon for Module 1?** *If not, please give reasons why:*	☐	☐
Did you go through the Student Summary with your class for Module 1, or instruct them to download it?	☐	☐
On average, how would you rate the level of engagement of your students with this module? ❑ Very engaged ❑ Somewhat engaged ❑ Neither engaged nor disengaged ❑ Somewhat disengaged ❑ Very disengaged		
Which activities did your students complete? ❑ What's in the fridge: online activity ❑ The Health4Life app download (homework task, recommended) ❑ Stop and Think: Healthy food choices ❑ Question time, screen time ❑ Sleep and me		
Did you prompt students to download the Health4Life app during class time? *If not, please give reasons why (e.g. school policy about mobile phones, lack of time):*	☐	☐
Did you encourage or remind students to use the Health4Life app outside of class time? *If so, how?*	☐	☐
Do you have any comments / concerns about Module 1? (*Please explain)*	☐	☐

MODULE 2	**Yes**	**No**
Did your students complete the online *Health4Life* cartoon component for Module 2?	☐	☐
Did your students complete the *whole* online cartoon for Module 2? *If not, please give reasons why:*	☐	☐
Did you go through the Student Summary with your class for Module 2, or instruct them to download it?	☐	☐
On average, how would you rate the level of engagement of your students with this module? ❑ Very engaged ❑ Somewhat engaged ❑ Neither engaged nor disengaged ❑ Somewhat disengaged ❑ Very disengaged		
Which activities did your students complete? ❑ What physical activities do you like? ❑ Alcohol and smoking quiz ❑ Alcohol, smoking and young people ❑ Step counter		
Did you prompt students to download the Health4Life app during class time? *If not, please give reasons why (e.g. school policy about mobile phones, lack of time):*	☐	☐
Did you encourage or remind students to use the Health4Life app outside of class time? *If so, how?*	☐	☐
Do you have any comments / concerns about Module 2?	☐	☐

MODULE 3	**Yes**	**No**
Did your students complete the online *Health4Life* cartoon component for Module 3?	☐	☐
Did your students complete the ***whole* online cartoon for Module 3?** *If not, please give reasons why:*	☐	☐
Did you go through the Student Summary with your class for Module 3, or instruct them to download it?	☐	☐
On average, how would you rate the level of engagement of your students with this module? ❑ Very engaged ❑ Somewhat engaged ❑ Neither engaged nor disengaged ❑ Somewhat disengaged ❑ Very disengaged		
Which activities did your students complete? ❑ Interactive quiz on teen drinking and smoking ❑ Homework: My health journey so far (recommended) ❑ Myths and facts about alcohol and tobacco ❑ Using social media responsibly		
Did you prompt students to download the Health4Life app during class time? *If not, please give reasons why (e.g. school policy about mobile phones, lack of time):*	☐	☐
Did you encourage or remind students to use the Health4Life app outside of class time? *If so, how?*	☐	☐
Do you have any comments / concerns about Module 3?	☐	☐

MODULE 4	**Yes**	**No**
Did your students complete the online *Health4Life* cartoon component for Module 4?	☐	☐
Did your students complete the ***whole* online cartoon for Module 4?** *If not, please give reasons why:*	☐	☐
Did you go through the Student Summary with your class for Module 4, or instruct them to download it?	☐	☐
On average, how would you rate the level of engagement of your students with this module? ❑ Very engaged ❑ Somewhat engaged ❑ Neither engaged nor disengaged ❑ Somewhat disengaged ❑ Very disengaged		
Which activities did your students complete? ❑ Activity all around you ❑ SMART goals ❑ Sugary drinks quiz ❑ Physical Activity researcher (homework)		
Did you prompt students to download the Health4Life app during class time? *If not, please give reasons why (e.g. school policy about mobile phones, lack of time):*	☐	☐
Did you encourage or remind students to use the Health4Life app outside of class time? *If so, how?*	☐	☐
Do you have any comments / concerns about Module 4?	☐	☐

MODULE 5	**Yes**	**No**
Did your students complete the online *Health4Life* cartoon component for Module 5?	☐	☐
Did your students complete the ***whole* online cartoon for Module 5?** *If not, please give reasons why:*	☐	☐
Did you go through the Student Summary with your class for Module 5, or instruct them to download it?	☐	☐
On average, how would you rate the level of engagement of your students with this module? ❑ Very engaged ❑ Somewhat engaged ❑ Neither engaged nor disengaged ❑ Somewhat disengaged ❑ Very disengaged		
Which activities did your students complete? ❑ Healthy, happy zzzs ❑ Sleep plan ❑ What's in my food? ❑ Keeping track (homework)		
Did you prompt students to download the Health4Life app during class time? *If not, please give reasons why (e.g. school policy about mobile phones, lack of time):*	☐	☐
Did you encourage or remind students to use the Health4Life app outside of class time? *If so, how?*	☐	☐
Do you have any comments / concerns about Module 5?	☐	☐

MODULE 6	**Yes**	**No**
Did your students complete the online *Health4Life* cartoon component for Module 6?	☐	☐
Did your students complete the ***whole* online cartoon for Module 6?** *If not, please give reasons why:*	☐	☐
Did you go through the Student Summary with your class for Module 6, or instruct them to download it?	☐	☐
On average, how would you rate the level of engagement of your students with this module? ❑ Very engaged ❑ Somewhat engaged ❑ Neither engaged nor disengaged ❑ Somewhat disengaged ❑ Very disengaged		
Which activities did your students complete? ❑ The Big link ❑ A Healthy 24 hours ❑ Help Seeker ❑ Exercise your mood		
Did you prompt students to download the Health4Life app during class time? *If not, please give reasons why (e.g. school policy about mobile phones, lack of time):*	☐	☐
Did you encourage or remind students to use the Health4Life app outside of class time? *If so, how?*	☐	☐
Do you have any comments / concerns about Module 6?	☐	☐

Appendix 4.6: Student characteristics

Characteristic	
	Total (n = 214)
Age (mean, SD)	12.77 (0.48)
Gender n (%)	
Male	143 (67.5%)
Female	66 (31.1%)
Preferred not to disclose	3 (1.4%)
State n (% of participants)	
New South Wales	207 (96.7%)
Western Australia	7 (3.3%)
School year group	
Year 7	210 (99.1%)
Year 8	2 (0.9%)
Country born in	
Australia	199 (93.9%)
Other	13 (6.1%)
Main language at home	
English	210 (99.1%)
Other	2 (0.9%)
Grades – usually get in school	
90-100%	36 (17.0%)
80-89%	63 (29.7%)
70-79%	58 (27.4%)
60-69%	34 (16.0%)
50-59%	11 (5.2%)
49% and below	10 (4.7%)

Appendix 4.7: Student responses to quantitative evaluation survey questions

Student responses to quantitative survey questions	**Number agreeing (%)**
Rated Health4Life as good or very good	142/214 (66.4%)
Like learning this way (a little to a lot)	137/213 (64.3%)
Like stories in Health4Life cartoons (a little to a lot)	135/213 (63.4%)
Stories were relevant to own experiences (somewhat to completely)	111/213 (52.1%)
Information was helpful (somewhat to extremely)	140/213 (65.7%)
Skills and information will help them in future to be healthy (yes; somewhat to a great deal)	172/213 (80.8%)
Likely to use the skills and information in own life (likely to very likely)	129/213 (60.6%)
Would recommend Health4Life to friends (yes)	94/213 (44.1%)

Appendix 4.8: Teacher responses to quantitative evaluation survey questions

Teacher evaluation survey responses	Number agreeing (%)
Overall rating of Health4Life (good or very good)	14/16 (87.5%)
Rating of Health4Life compared to other school-based health education programs (better than most)	11/16 (68.8%)
Ease of implementing Health4Life internet-based component (easy to very easy)	14/16 (87.5%)
Ease of access to computer for Health and Physical Education classes (easy to very easy)	11/16 (68.8%)
Ability of cartoon stories to hold students' attention (well to very well)	13/16 (81.3%)
Students' ability to recall health information after cartoon-based stories (well to very well)	12/16 (75.0%)
Perceived students' liking of cartoon-based stories (liked a little to a lot)	12/16 (75.0%)
Educational quality of additional classroom activities in the online Teacher Centre (good to very good)	14/16 (87.5%)
Ease of use of online Teacher Centre to prepare activities for class lessons (easy to very easy)	15/16 (93.8%)
How well additional classroom activities helped to reinforce the health information to students (well to very well)	12/16 (75.0%)
Likelihood of using Health4Life as a teacher resource in the future (likely to very likely)	9/16 (56.3%)
Likelihood of recommending Health4Life to others (likely to very likely)	8/16 (50.0%)

Appendix 4.9: Summary of engagement with Health4Life components based on teacher logbook responses

Component	Description	Delivery method/Format	Completion/reach
Cartoon storylines	20-minute cartoon storylines that teach key prevention messages.	Online via *Health4Life* website	**Module 1**: 16/16 (100%); *engaged 93.8% **Module 2**: 16/16 (100%); *engaged 93.8% **Module 3**: 15/15 (100%); *engaged 100% **Module 4**: 15/15 (100%); *engaged 86.7% **Module 5**: 14/15 (93.3%); *engaged 93.3% **Module 6**: 12/14 (85.7%); *engaged 85.7%
Summary sheets	Evidence-based summary sheets for students and teachers.	Online PDF	**Module 1**: 11/16 (68.8%) **Module 2**: 11/16 (68.8%) **Module 3**: 14/15 (93.3%) **Module 4**: 12/15 (80%) **Module 5**: 13/15 (86.7%) **Module 6**: 10/14 (71.4%)
Activities (offline)	Activities to promote self-management and interpersonal skills. In modules 1-4, a specific activity is marked as the recommended task.	Offline; mixture of paired interviews, group work, class discussion, and worksheet format.	**Module 1**: (50%-87.5%) **Module 2**: (25%-100%) **Module 3**: (20%-100%) **Module 4**: (80%-100%) **Module 5**: (20%-100%) **Module 6**: (64.3%-100%)
Activities (online)	One interactive activity per module to reinforce learning from cartoon.	Online interactive activity e.g. game, quiz, interactive worksheet	**Module 1**: *What's in the Fridge?* (13/16; 81.3%) **Module 2**: *What physical activities do you like?* (recommended) (13/16; 81.3%) **Module 3**: *Interactive quiz on teen drinking and smoking* (13/15; 86.7%) **Module 4**: *Activity All Around You* (13/15; 86.7%) **Module 5**: *Healthy, happy zzz's* (10/15; 66.7%) **Module 6**: *The Big Link* (9/14; 64.3%)

**Engagement percentages reflecting the proportion of students who were "somewhat to very engaged" with the component*

Appendix 5

Supplementary materials for Chapter 6

Appendix 5.1: OurFutures Alcohol Module lesson content summary

Lesson	Content
1	• Standard drinks. • The Australian guidelines to reduce health risks from drinking alcohol. • Alcohol, the law, and underage drinking. • Responsible drinking and how to stay safe. • Societal pressures and expectations to drink alcohol.
2	• Prevalence and patterns of alcohol use in young people. • Reasons why young people choose to or choose not to consume alcohol. • Positive alternatives to using alcohol, including alcohol-free social activities. • Myths about alcohol.
3	• Short- and long-term risks of drinking too much alcohol. • Potential risks and harms in common teenage drinking scenarios. • Ways to prevent harm in common teenage drinking scenarios. • Sources of help for young people, including seeking help from a school counsellor.
4	• The myths and facts about alcohol. • Alcohol advertising tactics and regulations.
5	• Alcohol refusal skills. • Ways to minimise alcohol consumption. • Decision-making about whether to consume alcohol. • Examining different views on the consumption of alcohol. • Keeping yourself and others safe when using alcohol.
6	• Recognising the signs of an alcohol-related medical emergency. • What to do and who to contact if there is an alcohol-related medical emergency. • First aid procedures when someone is unwell after drinking alcohol.

Appendix 5.2: Alcohol factsheet (English version of original provided for publication purposes)

Alcohol Factsheet

THE UNIVERSITY OF SYDNEY

Pontificia Universidad JAVERIANA Bogotá

What is alcohol?

Alcohol is a colourless liquid contained in wine, beer, spirits and other alcoholic drinks. Alcohol is a depressant because it slows down the way your brain relays information to the rest of the body. The legal age to buy alcohol in Australia is **18 years** of age.
Type of alcohol include:

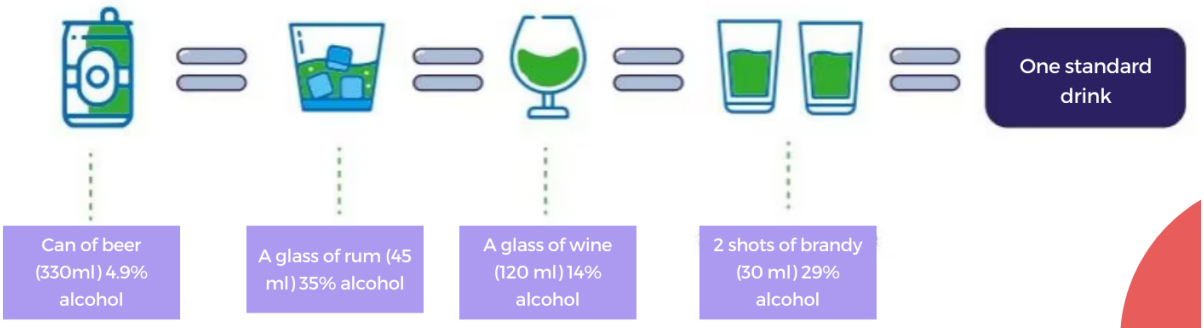
- Beer
- Wine, including sparkling (fizzy) wines
- Cider
- Spirits (e.g. vodka, gin, rum, bourbon, whisky)
- Liqueurs (e.g. coffee flavoured alcohol)
- Pre-mixed drinks (e.g. cans of bourbon and cola)
- Fortified wines (e.g. port, sherry)

How long do the effects of alcohol last?

The effect of alcohol varies greatly from person to person and depends on things like gender, age, size, mood, medical conditions, and whether it is taken together with other drugs.
Drinks also vary greatly in how much alcohol they contain. The more alcohol a drink contains, the longer it takes for the body to process..

The World Health Organisation (WHO) recommends **10 grams of ethanol (pure alcohol) per standard drink.** As you can see in the image below, different drinks contain different amounts of alcohol.

Figure 1: Number of standard drinks in alcoholic beverages.



Approximate standard drink in Colombia. - Photo: Banco Av. Villas

What are the effects of alcohol?

Some harms are linked to drinking too much on one occasion (e.g. injuries, unsafe sex, alcohol poisoning) while other harms are linked to regular drinking (e.g. liver problems, addiction).

The effects of alcohol can be immediate or long-term, as listed in the image on the next page.

For more information, contact:

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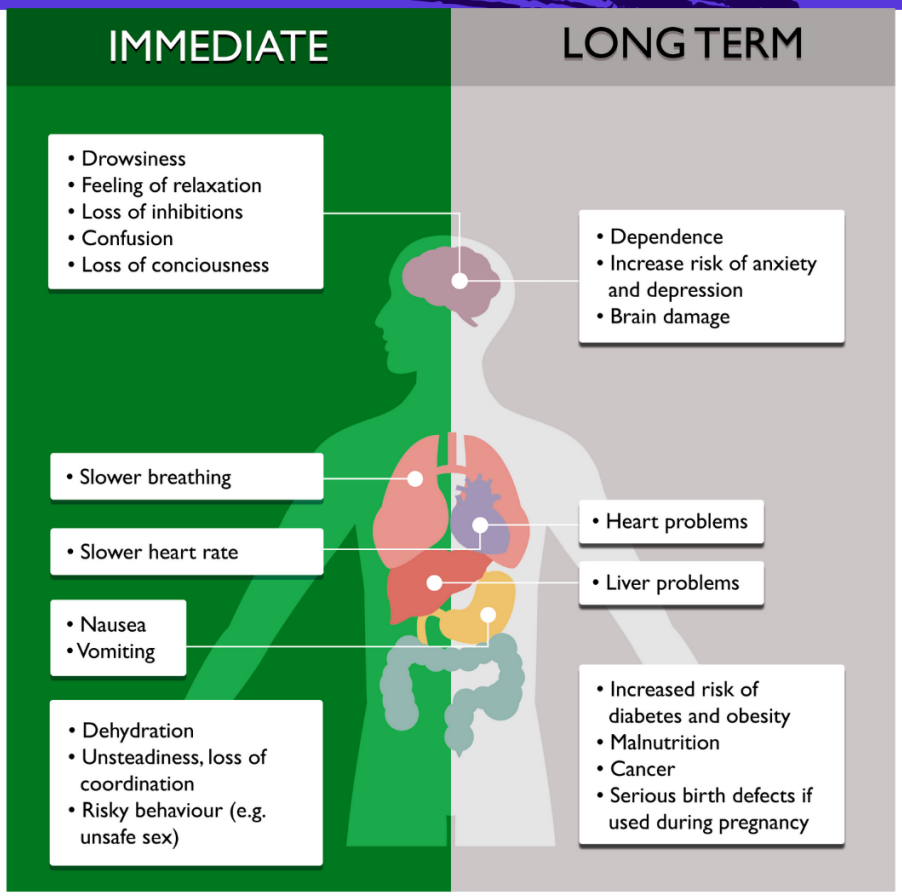

Young people and alcohol

The human brain is still developing and maturing well into the 20s. **Research findings show that drinking alcohol during the teenage years can disrupt healthy brain development**. For this reason, teenagers are advised to avoid drinking for as long as possible. Starting to drink at an earlier age also places young people at greater risk of developing alcohol-related problems later in life.

Alcohol use among young Colombians

According to the National Survey on the Consumption of Psychoactive Substances of Colombia 2019 (ENCSPA), 46.3% of young people between 12 and 17 years old have consumed alcohol at least once, 32% have consumed alcohol in the last 12 months and on the 12.1% in the last 30 days.

It is important that young people understand the effects of alcohol and the potential negative consequences so that they can make informed decisions.

Evidence base

This factsheet is based on the Positive Choices alcohol factsheet, available here: https://positivechoices.org.au/teachers/alcohol-factsheet.

For more information, contact:

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Appendix 5.3: Student Focus Group Guide

Part 1: Exploring attitudes and perceptions about alcohol use (~20 minutes)

1. What do you know about alcohol?
    - Is there more alcohol in a unit of beer than in a unit of spirits?
2. Do you believe that young people (under the age of 18) can get into risky situations when consuming alcohol?
    - Why/not
3. Do you believe that alcohol consumption is harmful to your body/health?
    - Why/not
4. Do you think it is common for young people your age to consume alcohol?
    - Would it be common for young people your age to engage in other health-risk behaviours such as tobacco smoking or e-cigarette use, eating nutrient-poor food (e.g. junk food/fried foods)?
5. What are some of the main reasons that someone your age might choose to consume alcohol?
5. What are some of the main reasons that someone your age might choose not to consume alcohol?
6. Where, or in what situations, do people your age most commonly consume alcohol?
    - In these situations, would it be common to consume alcohol in addition to eating nutrient-poor food (e.g. junk food/fried foods) and/or smoke tobacco cigarettes or vape?

Part 2: Going through one lesson from the OurFutures Alcohol Module (~25 minutes)

- The researchers will display one of OurFutures Alcohol Module cartoon lessons on a screen and click through each slide (approximately 20 minutes).
- As the speech bubbles are translated into Spanish using the OurFutures Kanzi in-built translation software, students will be able to read the speech bubbles on each slide (approximately 100 slides in total).
- Following the cartoon, the researchers will display one of the interactive activities on a screen and prompt students to respond to the questions (approximately 5 minutes).

Part 3: Relatability and acceptability of OurFutures, brainstorming new ideas for characters and storylines (~45 minutes)

<u>General feedback</u>

7. Overall, how would you rate the OurFutures? (e.g. very good, average, very poor)

<u>Storylines</u>

8. How much did you like the storylines in the lessons? (e.g. liked a lot, disliked a little)
9. Were there any scenarios you found especially interesting or memorable?

- Why was this especially memorable?
- Would you change anything about the way this scenario was addressed in the cartoon?

10. How believable and realistic were the storylines for people your age? (e.g. completely believable and realistic, unsure, somewhat unbelievable and realistic)
11. What changes would you make to make the storylines more believable or realistic?
    a) E.g. the place where alcohol consumption would occur (e.g., at school, at someone's house, at a party etc.)
    b) E.g. What other characters would be involved and what would their role be?
    c) How many of the friendship group would you expect to bring alcohol?
    d) Where do you think they would have gotten their alcohol from?
    e) What problems might the characters face?

If students can't identify any, ask "what ifs" (e.g., What if someone didn't want to consume alcohol but they were being peer pressured at a party?)

d. How might they overcome those problems?

<u>Characters</u>

12. How much did you like the characters in the lesson(s)? (e.g. liked a lot, disliked a little)
13. Which character do you relate to most and why?
14. Do you think other people in your age group would be able to relate to the characters? Why/why not?
    a) Are they representative of young people you know? How/why not?
        - Do they have different personality traits?
        - Do they look the same?
    b) Are they representative of who you think would consume / not consume alcohol? How/why not?
        - Do they display the same behaviours e.g. other health risk behaviours (e.g. tobacco smoking, e-cigarette use, nutrient-poor food consumption)? Do they experience negative effects from any of these behaviours and/or alcohol use?
        - Do they display the same health seeking behaviours e.g. staying physically active
        - When worried about their own or someone else's alcohol consumption, do they seek out advice or help? How/why not?
        - What is their friendship group like? (e.g. do they have many friends? What are their friends into? Where do they hang out?)
        - What is their home life like? (e.g., Do they live with a parent/s? do they have siblings?)
    c) What are some other possible names for these characters?
15. Is there anything about the characters you would want to change?
16. Do you feel represented in the cartoons? If not, what could be included to improve the representation?

<u>Language</u>

17. Do you think the language used in the cartoon scripts was appropriate for young people your age?
18. Are there any specific words or phrases that you would like to see included in the cartoons?

Appendix 5.4: Teacher Interview Guide

Part 1: Exploring attitudes and perceptions about alcohol use and prevention (~15 minutes)

1. What role does alcohol have in Colombian culture?
    a. Is it normalised? (for young people to consume alcohol with family?)
2. Do you believe it is common for Colombian youth to drink alcohol?
    a. Does it differ by geographical location or socioeconomic status e.g. cities vs rural areas, low SES vs high SES?
3. Would initiation of alcohol use coincide with other health risk behaviours such as tobacco smoking or e-cigarette use, eating nutrient-poor food (e.g. junk food/fried foods)? Why/why not?
4. Do you know of evidence-based alcohol education / prevention resources available and accessible to Colombian youth?
    a. What are they? Who facilitates?
        i. Do you feel comfortable sharing these?
5. With regards to the current alcohol curriculum for Colombian youth, could you please describe what it involves and how it is taught?
    a. What topics are covered? (e.g. harm minimisation strategies)
    b. How much time is allocated to deliver alcohol curriculum?
    c. How is it delivered? (e.g. via prescribed texts in class, or internet resources/programs)
6. How likely are you to use an evidence-based digital alcohol prevention program specific to Colombian youth when teaching Colombian youth about alcohol?
    a. Do you foresee any barriers to using such a program?

Part 2: Relatability and acceptability of OurFutures, brainstorming new ideas for characters and storylines (~45 minutes)

1. Which lesson(s) did you view? (i.e. 1-6)
    a. Did you review any of the other resources e.g. teacher and student summaries, activities?
2. Overall, how would you rate the lessons? (i.e. very good, average, very poor)
3. What did you like or not like?
4. How believable and relevant do you think that the scenarios and examples within the cartoons would be for Colombian youth aged 11 to 13 years? (regarding lesson reviewed)
    a. Why/Why not?
    b. Ask about storylines and characters, anything to change, add (e.g. representation of different characters, was it believable and realistic)
5. Do you think the language used in the cartoon scripts was appropriate for Colombian youth aged 11 to 13 years?
    a. Are there any specific words or phrases that you would like to see included in the cartoons?

6. Do you think the educational content is reasonable and appropriate for Colombian youth aged 11 to 13 years?
    a. Why/Why not?
7. Do you think that most Colombian youth aged 11 to 13 years would be able to understand and remember the concepts being taught?
    a. Why/Why not?
8. Do you think the length of each lesson (20 minutes plus an optional 20-minutes of activities) and the program (6 lessons) adequately covers the concepts being taught?
    a. Why/Why not?
9. Do you like the format in which this is delivered?
10. Would this be a program which you would deliver with your students?
    a. Why/Why not?
    b. E.g. what would make it more enticing?
11. Would you be interested in participating in a co-design workshop (e.g. design characters, review or change cartoon scripts) aimed at creating an adaptation to the OurFutures Alcohol Module?
    a. If so, would you also be interested in participating in a pilot trial of the adapted OurFutures Alcohol Module?
    b. If you would like to be contacted to participate in the co-design workshop and/or pilot trial please let us know your preferred contact details (i.e. address, email or phone number)

Appendix 5.5: Teacher Online Survey

Part 1: Information About You

Number of years' experience teaching	

Part 2: Exploring attitudes and perceptions about alcohol use

1. What role does alcohol have in Colombian culture? Is it normalised? (for young people to consume alcohol with family etc?) *Please record as many reasons as you can think of.*

2. Do you think it is common for Colombian youth to drink alcohol?
    - Yes
    - No

3. Would initiation of alcohol use coincide with other health risk behaviours such as tobacco smoking or e-cigarette use, eating nutrient-poor food (e.g. junk food/fried foods)? Why/why not?
    - Yes
    - No

Please explain response to this question (i.e. why/why not?)

4. Is consumption of alcohol among Colombian youth similar across those living in different geographical locations i.e. cities vs rural areas?
    - Not at all similar
    - Somewhat similar
    - Very similar
    - Extremely similar

Please explain your response to this question

_____

_____

_____

_____

5. Is consumption of alcohol among Colombian youth similar across those from different socioeconomic status groups e.g. low SES vs high SES?
    - Not at all similar
    - Somewhat similar
    - Very similar
    - Extremely similar

Please explain your response to this question

_____

_____

_____

_____

6. Do you know of evidence-based alcohol education / prevention resources available and accessible to Colombian youth?
    - Yes
        - Please explain your response to this question (e.g. what are they and who facilitates them?)

          _____

          _____

          _____

          _____
    - No
    - Unsure

7. With regards to the current alcohol curriculum for Colombian youth, could you please describe what it involves and how it is taught? *Please include information on the topics covered (e.g. harm minimisation strategies), time allocated to deliver the alcohol curriculum, and method of delivery (e.g. via prescribed texts in class, or internet resources/programs)*

8. How likely are you to use an evidence-based digital alcohol education program specific to Colombian youth when teaching Colombian youth about alcohol?
    - Not at all
    - Slightly
    - Moderately
    - Very
    - Extremely

Please explain your response to this question (e.g. barriers or motivators):

<u>Part 3: The OurFutures Alcohol Module</u>

After viewing the cartoon lessons please answer the following questions.

12. Please indicate which of the following you viewed (cartoons mandatory, others are optional):

Lesson 1 <if applicable> ☐ Online Cartoon ☐ Teacher Summary ☐ Student Summary ☐ Activities	Lesson 2 <if applicable> ☐ Online Cartoon ☐ Teacher Summary ☐ Student Summary ☐ Activities
Lesson 3 <if applicable> ☐ Online Cartoon ☐ Teacher Summary ☐ Student Summary ☐ Activities	Lesson 4 <if applicable> ☐ Online Cartoon ☐ Teacher Summary ☐ Student Summary ☐ Activities
Lesson 5 <if applicable> ☐ Online Cartoon ☐ Teacher Summary ☐ Student Summary ☐ Activities	Lesson 6 <if applicable> ☐ Online Cartoon ☐ Teacher Summary ☐ Student Summary ☐ Activities

FIRST IMPRESSIONS

1. **Overall, how would you rate the lessons?**
   - Very good
   - Good
   - Average
   - Poor
   - Very poor

2. **What are your first impressions of the module?**

3. **What did you like?**

4. **What didn't you like?**

ACCEPTABILITY FOR STUDENTS

5. **Do you think that the scenarios and examples within the cartoons would be believable and relevant for Colombian youth aged 11 to 13 years?**

Lesson 1 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 2 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 3 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 4 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 5 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 6 <if applicable>

- Yes
- No

Why/Why Not?

LANGUAGE

6. **Do you think the language used in the cartoon scripts was appropriate for Colombian youth aged 11 to 13 years?** Please recommend any specific words or phases that should be included

Lesson 1 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 2 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 3 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 4 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 5 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 6 <if applicable>

- Yes
- No

Why/Why Not?

EDUCATIONAL CONTENT

7. **Do you think the educational content is reasonable and appropriate for Colombian youth aged 11 to 13 years?**

Lesson 1 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 2 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 3 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 4 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 5 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 6 <if applicable>

- Yes
- No

Why/Why Not?

LEARNING

8. **Do you think that most Colombian youth aged 11 to 13 years would be able to understand and remember the concepts being taught?**

Lesson 1 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 2 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 3 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 4 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 5 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 6 <if applicable>

- Yes
- No

Why/Why Not?

LENGTH

9. **Do you think the length of each lesson (20 minutes plus an optional 20-minutes of activities) and the program (6 lessons) adequately covers the concepts being taught?**

Lesson 1 <if applicable>

- Yes

- No

Why/Why Not?

Lesson 2 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 3 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 4 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 5 <if applicable>

- Yes
- No

Why/Why Not?

Lesson 6 <if applicable>

- Yes
- No

Why/Why Not?

FORMAT

10. Do you like the format in which the *OurFutures* program is delivered?

- Strongly disagree
- Disagree
- Neither disagree or agree
- Agree
- Strongly agree

Please explain your response to this question

_____

_____

_____

Intention to use

11. Would this be a program which you would deliver with your students?

- Strongly disagree
- Disagree
- Neither disagree or agree
- Agree
- Strongly agree

Please explain your response to this question

_____

_____

_____

Appendix 5.6: Post Focus Group Evaluation Survey

Part 1: Information About You

What is your gender?	Female	Male	Non-binary	Other

What sex were you assigned at birth? (i.e. the one that was originally specified on your birth certificate)	Female	Male	Prefer not to answer

What is your age?	

Below you will see questions asking for your feedback on the OurFutures cartoons. Your responses to these questions are optional and you can respond to as little or as many as you like.

Part 2: The OurFutures Cartoons

Thinking about the OurFutures cartoon lessons that you viewed today:

11. Overall, how would you rate the OurFutures lessons?

☐ Very Good ☐ Good ☐ Average ☐ Poor ☐ Very Poor

12. How much did you like the storylines in the lessons?

☐ Liked a lot
☐ Liked a little
☐ Neither liked nor disliked
☐ Disliked a little
☐ Disliked a lot

Please list any changes you would make to the storylines:

13. How believable and realistic were the storylines for people your age?

☐ Completely believable and realistic
☐ Somewhat believable and realistic
☐ Unsure
☐ Somewhat unbelievable and realistic
☐ Completely unbelievable and realistic

Please list any changes to make the storylines more believable or realistic (e.g. the location where alcohol is consumed, the characters that would be involved and their relationship, the issues they may face and how they overcome such issues):

14. How much did you like the characters in the lessons?

☐ Liked a lot
☐ Liked a little
☐ Neither liked nor disliked
☐ Disliked a little
☐ Disliked a lot

Which character did you like the most? _____

15. How relatable were the characters in the lessons?

☐ Extremely relatable
☐ Very relatable
☐ Neutral
☐ Very unrelatable
☐ Not at all relatable

Please list any changes you would make to the characters (e.g. their personality traits, behaviours they engaged in such as eating healthy/unhealthy food, appearance, friendship group, names, more diversity of cultural backgrounds or different beliefs):

16. Do you think the language used in the cartoon scripts was appropriate for young people your age?

- ☐ Extremely appropriate
- ☐ Very appropriate
- ☐ Neutral
- ☐ Very inappropriate
- ☐ Not at all appropriate

Please list any changes you would make to the language used in the cartoons (e.g. specific words or phrases that should be used):

	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
17. Do you think that other people your age will understand the information in the lessons?					
18. Do you think other people your age will like the characters?					
19. Do you think that other people your age will find the cartoons an engaging way to learn?					

11. Are there any other changes that you would like to see, even minor things?

Appendix 5.7: Summary of Focus Group Participant Characteristics

School grade (by focus group)	Age (years)	Number of participants	Gender (%)		
			Male	Female	Other
Grade 5	11-13 (M=11.78 years; SD=0.63)	10	50	50	0
Grade 6	11-14 (M=12.33 years; SD=1.28)	6	67	33	0
Grade 7	13-15 (M=13.70 years; SD=0.71)	10	60	30	10
Total		26	59	38	3

Appendix 5.8: Summary of teacher questionnaire and interview data on attitudes and perceptions regarding alcohol consumption among young people and education in Colombia

Question	Total N (%)
Is it common for Colombian youth to drink alcohol? (% yes)	10 (100%)
Would initiation of alcohol consumption coincide with other risk behaviours e.g. tobacco smoking, use e-cigarettes, eat junk food? (% yes)	10 (100%)
Is alcohol consumption among Colombian youth similar across those living in different geographical locations i.e. cities vs rural areas? (% very/extremely similar)	6/9 (67%)
Is alcohol consumption among Colombian youth similar across those from different socioeconomic status groups? (% very/extremely similar)	4/10 (40%)
Do you know of evidence-based alcohol education / prevention resources available and accessible to Colombian youth? (% yes)	1/10 (10%)
How likely are you to use an evidence-based digital alcohol education program specific to Colombian youth when teaching Colombian youth about alcohol? (% very/extremely likely)	8/10 (80%)

Appendix 5.9: In-depth description of qualitative findings from Part 1 on the attitudes and perceptions towards alcohol use held by young Colombian people and their teachers

i) Alcohol has cultural significance in Colombia.

According to both teachers and students, alcohol holds a prominent and symbolic role in Colombian culture. Celebratory occasions, from family gatherings to social events, often involve alcohol consumption. Focus group participants frequently shared that their first experience trying alcohol was during special events such as birthdays or Christmas. Teachers discussed the pervasive influence of alcohol in Colombian culture and its early exposure among its youth, and suggested that some parents view introducing alcohol early as promoting responsible consumption or as a cultural practice.

> '*Unfortunately, alcohol is part of Colombian culture, it's seen in any kind of gathering, from beer to cocktails. It's also very regrettable that it's considered normal for children and teenagers to consume alcoholic beverages at family gatherings, with some saying it's better for them to get used to it.*' (Teacher 6)

Grade 7 participants generally perceived that parties among their age group always involved alcohol. This aligned with teachers' comments on a societal expectation in Colombia that a celebration or gathering is incomplete without alcohol.

> '*A party without alcohol no, [doesn't exist].*' (Grade 7 focus group)

> '*…here in Colombia there is, perhaps, the custom or the culture that without alcohol one cannot have a good time at a party, in a meeting, in things like that. So, yes, generally the incidence of alcohol consumption in Colombia is very strong in any scenario*.' (Teacher 2)

ii) Developmental stages and initiations

Teachers unanimously perceived alcohol consumption as common among Colombian youth, with initiation often occurring in family settings with minimal geographical variations, although the type of alcohol consumed may differ. In urban areas, young people have access to a variety of alcoholic beverages, while rural areas see a tradition of consuming local drinks like masato, chicha, or guarapo, which depending on the fermentation time, can have high alcohol content. Socioeconomic status, on the other hand, was generally perceived to shape both the onset age and type of alcohol consumed, with high-income families affording non-adulterated alcohol, while those from lower socioeconomic levels may resort to consuming adulterated alcohol or creating mixtures.

> '*Alcohol consumption among young Colombians normally first occurs in family spaces, it is the grandparents, uncles and cousins who accompany this first consumption, [rather than] differences in consumption by geographical locations,…what changes in the socioeconomic strata is the type of liquor consumed, well children from low socioeconomic strata consume more beer or low-priced liquor, while those in higher socioeconomic strata consume higher quality and priced liquor.*' (Teacher 3)

> *'In rural areas, it is allowed by tradition. In the city, due to the greater supply and little parental control.*' (Teacher 7)

> '*...Honestly, my students drink to relieve the pressure they face. Students from other schools with less academic demand may drink for different reasons from a younger age, and their behaviour is somewhat sanctioned by society…Most of the kids I work with come from high-income families that can afford at least non-adulterated alcohol. In lower economic levels, there may be cases of consuming adulterated alcohol or making mixtures.* (Teacher 1)

In focus groups, participants generally perceived alcohol consumption was common among their peers, particularly the grade 7 group. Grade 5 participants associated the initiation age with family influence and parental consent, ranging from 10 to 15 years. Grade 7 participants rejected initiation before 10, indicating inappropriateness of introducing alcohol at that age, suggesting an initiation age between 12 and 16. In contrast, grade 6 participants associated alcohol consumption with ages 16 and 17; however, contextual factors such as exposure to negative role models or neighbourhood circumstances influenced their perceptions.

> '*...over there sometimes [they start drinking] from the age of 14, and due to bad influence.*'(Grade 6 focus group)

> '*I live in [a neighbourhood where you] …even see small children like 8, 9 years old [drink alcohol]*. (Grade 6 focus group)

iii) Alcohol consumption influences and practices

Focus group participants perceived a range of motivations for alcohol consumption among their peers including experiencing feelings of depression, seeking independence, to be cool, to rebel, or satisfy curiosity. Social modelling, including adults consuming alcohol in spaces with young people was perceived to tempt young people to drink. Participants noted that young people often consume alcohol in settings where adults are drinking, and witnessing peers enjoy alcohol was perceived as a motivator for others to try it.

> '*Also because I know, you also see several young people, and it seems that the others inspire them to try that, and well, they seem to like it, I don't know, and they keep trying it.*' (Grade 6 focus group)

Furthermore, participants across all grades perceived the combination of alcohol with other substances as common, such as cocaine, cannabis, cigarettes, e-cigarettes, energy drinks, and junk food. Although grade 5 participants primarily discussed this phenomenon in the context of adults whereas grades 6 and 7 generalised it to people engaging in alcohol consumption.

> '*What I know is that also when a person drinks a lot of alcohol it causes them to try certain amounts of substances like "perico", like cocaine.*' (Grade 6 focus group)

Teachers also commented on the commonality of young people combining alcohol with other substances, particularly cigarettes and other psychoactive substances.

> '*…it's very, very evident that they consume alcohol along with cigarettes initially, or in addition to that, they consume some other type of psychoactive substance, either to enhance the effect of alcohol or to keep themselves a bit stabilised*.' (Teacher 2)

iv) Health awareness and risk perception

Focus group participants universally perceived there are immediate risks when young people consume alcohol, such as violence and getting robbed. In grades 6 and 7, this perception extended to encompass long-term dangers, specifically cancer, traffic accidents, and death.

> '*There are some [people] who know how to handle alcohol, and others who don't, those who don't know how to handle alcohol, …go crazy, they pick fights, …those who don't know how to handle alcohol, it's just that they fall asleep on the street and that's why they get robbed*' (Grade 6 focus group)

> Interviewer: '*[You said] that it is harmful to health. What else?*
> Participant: *[It] causes cancer.*
> Interviewer: *it causes cancer, yes.*
> Participant: *An addiction.'*
> (Grade 7 focus group)

Despite these concerns expressed by focus group participants, some teachers perceived a very low-risk perception associated with alcohol use in Colombian society, especially among minors, highlighting family influence as a contributing factor.

> '*Simultaneously, in people's risk perception scales regarding how serious consuming alcohol is, it is inversely proportional. Among all drugs, alcohol has the lowest risk perception, around 10% or a little less. This high frequency of consumption, especially among minors, is often linked to family influence*.' (Teacher 1)

Appendix 5.10: Summary of student questionnaire data

Question	n (%)
Overall rating of lesson (% good/very good)	25/26 (96%)
How much did you like the storyline? (% liked a little/lot)	25/26 (96%)
How believable and realistic was the storyline? (% completely/somewhat)	22/25 (88%)
How much did you like the characters in the lesson? (% liked a little/lot)	25/26 (96%)
How relatable were the characters in the lessons? (% very/extremely relatable)	16/26 (62%)
Do you think the language used in the cartoon scripts was appropriate for young people your age? (% very/extremely appropriate)	15/26 (58%)
Do you think that other people your age will understand the information in the lessons? (% agree/strongly agree)	13/22 (59%)
Do you think other people your age will like the characters? (% agree/strongly agree)	9/21 (43%)
Do you think that other people your age will find the cartoons an engaging way to learn? (% agree/strongly agree)	13/22 (59%)

Appendix 5.11: Summary of teacher questionnaire and interview data on the relatability and acceptability of the *OurFutures Alcohol Module* within the Bogotán context

Question	Total (n=10), n (%)
Overall rating of lesson (% good/very good)	8/9 (89%)
Do you think that the scenarios and examples within the cartoons would be believable and relevant for Colombian youth aged 11 to 13 years? (% yes)	7/10 (70%)
Do you think the language used in the cartoon scripts was appropriate for Colombian youth aged 11 to 13 years? (% yes)	6/10 (60%)
Do you think the educational content is reasonable and appropriate for Colombian youth aged 11 to 13 years? (% yes)	9/10 (90%)
Do you think that most Colombian youth aged 11 to 13 years would be able to understand and remember the concepts being taught? (% yes)	4/7 (57%)
Do you think the length of each lesson (20-minutes plus optional 20-minutes of activities) and the program (6 lessons) adequately covers the concepts being taught? (% yes)	7/10 (70%)
Do you like the format in which the OurFutures program is delivered? (% agree/strongly agree)	5/7 (71%)
Would this be a program which you would deliver with your students? (% agree/strongly agree)	8/10 (80%)

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