Social networks of adolescents and sexual behaviours

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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.

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Abstract

Background

Adolescence is a period of human life between childhood and adulthood that involves enormous physical, mental and social changes. Ongoing brain maturation means many adolescents' capacity to manage these changes is not fully developed, leaving them vulnerable to health risks associated with their social interactions. Simultaneously, social networks are crucial in adolescents' lives; online and offline social networks increasingly overlap, and the social networks of adolescents are expanding beyond families like never before.

Rapid growth in use of social networking platforms and communication devices has brought both benefits and drawbacks to the lives of adolescents, including their sexual behaviour. Healthy sexual development in adolescents is not well understood due to these and many other influencing factors. Recent developments in social network analysis (SNA) offer a better understanding of the interactions between human social networks and behaviours.

Social network analysis investigates the structure of a social network, such as its density and constraints, as well as the interactions of the people in the network. The strength of ties between network members, the distance between them, and individual characteristics (including position in the network) are units of analysis. This study applied SNA to a sample of Australian adolescents in order to understand how social networks affect their sexual behaviours.

Aims

In this study, data from the Social Networks and Agency Project (SNAP) were examined in order to explore:

- Patterns of interaction within personal networks at the individual level, the tie level, and the network level
- The association of network properties and sexual behaviours of adolescents
- The characteristics of people (alters) in the networks of adolescents
- The association between alters' variables and the sexual behaviours of adolescents.

Method

The SNAP study was a longitudinal cohort study conducted in Australia between August 2015 and December 2018. It collected data on the demographics, social networks, and sexual behaviours of 86 adolescents through three online surveys and a fortnightly online diary. The PhD candidate conducted secondary data analysis of the SNAP data. Social network variables were analysed using UCINET social network analysis software. Then, bivariate and multivariate logistic regression models were used to determine the associations between social network variables and sexual behaviour variables, and between alter's variables and sexual behaviours variables, at baseline, midline, and endline. Generalised estimation equation models were used to detect trends in these associations across the three time points.

Results

Participants were 15–17 years old and enrolled in grades 9–12 in high schools at the beginning of the study; 70% were female, and 50% reported sexual attraction to both males and females. Those who were sexually attracted to both sexes were more likely to report anal sex; those with higher

socioeconomic status were less likely to have condomless sex; and compared to male counterparts, female and other gender respondents were more likely to report unwanted sex.

Those with networks that had a stronger average tie strength (a combination of time spent and emotional intensity between two people) were more likely to have wanted sex and score higher in enjoying sex in cross-sectional analyses. Cross-sectional analyses showed that those in a network with a high ego density (percentage of all possible ties in a person's network that are present) were less likely to have casual sex partners and unwanted sex. They were also more likely to have wanted sex and scored higher in enjoyment of sex in longitudinal analyses.

Those who had higher efficiency (total number of nonredundant people reached by the primary contact) in the network were more likely to have multiple sexual partners and casual sex partners, and less likely to score high in enjoyment of sex. In longitudinal analysis, they were also less likely to have wanted sex and less likely to score high on enjoyment of sex. Those who showed higher centrality of betweenness (the frequency with which a person is on the shortest path between two other people in a network) were more likely to have casual sex partners. In longitudinal analysis, they were also less likely to have wanted sex and less likely to score high on enjoyment of sex.

Those who had more friends in the network were more likely to have their first sexual experience after the age of 16 years and scored higher on enjoyment of sex. Those who had a boyfriend/girlfriend in their networks were less likely to have unwanted sex and less likely to use condoms. Those who had more high school students in their network were more likely to have their first sexual experience after the age of 16 years. Those who had university students in their networks were more likely to have casual sex partners and unwanted sex. Those who had people in their network with whom they were close or very close were more likely to have their first sexual experience after the age of 16 years and less likely to have casual and multiple sexual partners.

The findings lead to the conclusion that well-connected networks, made up of friends with similar educational backgrounds and with whom they are close, support adolescents to practise healthy sexual behaviours. These findings suggest that parents, teachers, health care workers and policymakers should seek to create safe networks for adolescents and encourage them to select safer networks. In addition, educators should craft initiatives that give adolescents the life skills to developing safely in a rapidly changing communications technology context.

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Abbreviations

AOR	Adjusted odds ratio
GEE	Generalized estimating equation
HIV	human immunodeficiency virus
IRR	Incidence rate ratio
LGBT	Lesbian, gay, bisexual, and transgender
NA	Not applicable
NOS	Newcastle Ottawa Scale
OR	Odds ratio
SD	Standard deviation
SNA	Social Network Analysis
STI	Sexually transmissible infection
WHO	World Health Organization

1. Introduction

Adolescence

Adolescence is a developmental period of life which is unique due to the rapid and intense physical, cognitive, emotional and social changes. Adolescents undergo growth and maturation of reproductive, musculoskeletal, neurodevelopmental, endocrine, metabolic, immune, and cardiometabolic systems. Due to improved understandings of neurodevelopment and the widening gap between the onset of puberty and the age at which mature adult roles are attained, researchers have proposed that the term 'adolescence' be applied to those aged between 10 and 24 years (Patton et al., 2018; Sawyer et al., 2012; Temple-Smith, Moore, & Rosenthal, 2015).

There are substantial changes in brain development due to refinement of synaptic connectivity and maturation of long axon pathways that support functional integration of neural systems. Adolescents begin to take on the roles and responsibilities of adults including employment transition, financial autonomy, and life partnership (Patton et al., 2018; Temple-Smith et al., 2015), although their capacity for multidimensional thinking in a strategic manner is not fully developed (Blakemore & Choudhury, 2006). As a result, adolescents may engage in behaviours which may lead to increased health risk, particularly during emotionally salient circumstances. These include health risks associated with intimate sexual encounters (Viner RM, 2017).

There are a range of influencing factors on adolescent puberty such as biological, psychological, social, political, legal, philosophical, spiritual, and moral values. In recent decades, social media growth also has found to have an impact on adolescents' perception and attitude towards sexuality (Kar, Choudhury, & Singh, 2015). Adolescents expand their networks beyond the influence of family and parents towards peer networks, become increasingly aware of their sexuality, and begin to seek their own identities (Lamblin, Murawski, Whittle, & Fornito, 2017; Thomas W Valente, 2010). Their primary orientation changes to a reliance on peers as guidelines for attitudes and behaviour, to set goals and develop interpersonal skills. Social forces also shape adolescent sexuality by the setting of sexuality-related norms and values (Cislaghi & Shakya, 2018; Temple-Smith et al., 2015).

Sexuality is a core aspect of being human throughout the lifespan but has significance during adolescence with the onset of puberty, which is characterised by maturation of the reproductive organs and increase in sex drive. Secondary sexual characters are expressed in adolescents such as pubic hair, axillary hairs in both males and females. In males, enlargement of genitals, appearance of facial hair, and masculine shape appear. In females, breast development, first menstruation (known as menarche) and a female body shape appear (Fortenberry, 2013; Kar et al., 2015).

Adolescent sexuality is a normative process in development with the potential for positive or negative consequences (Feldmann & Middleman, 2002; Odii, Atama, Igwe, Idemili-Aronu, & Onyeneho, 2020). As well as physiological development, adolescents are struggling with the development of sexual identity, early intimate relationships, challenges associated with peer group expectations, and the influence of social media and broader societal messages about sex all shape adolescents' understandings about sex and sexuality (Feldmann & Middleman, 2002; Odii et al., 2020).

Sexual behaviour during adolescence

Throughout the world, partner sexual activity begins during the adolescent decade. Adolescents should have sexual activity that has pleasure and satisfaction, is free of pain, and has a negative effect (Harden, 2014). However, adolescents are at greater risk of unintended or negative sexual health consequences such as sexually transmitted infections (Feldmann & Middleman, 2002; Wangu & Burstein, 2017), early pregnancy (Kar et al., 2015; Wangu & Burstein, 2017), unplanned pregnancy (Slater & Robinson, 2014; Thompson, Davis, Pendleton, & Shlafer, 2020), unsafe abortion, and other psychosocial problems (Bhushan, Stoner, Groves, Kahn, & Pettifor, 2022).

Adolescents are often naturally curious about sex and may experiment with a range of adult behaviours, including sex (Feldmann & Middleman, 2002). Further, sexual behaviours that might be risky are often seen as positive or rewarding (Mesele et al., 2023). Insufficient sex education in early adolescence including the lack of proper sex education in schools and (Feldmann & Middleman, 2002; Odii et al., 2020) some traditional cultures in which sexuality is limited to discuss (Kar et al., 2015), (Mesele et al., 2023), and broken of social structure in early adolescence was also found to be contributing factors that adolescents engage in risky sexual behaviors (Feldmann & Middleman, 2002; Odii et al., 2020).

Social networks of adolescents

Social networks are defined as 'a pattern of friendship, advice, communication, or support' between individuals or groups of people within a social system (Thomas W Valente, 2010). The social network is a set of relations that encompasses a set of social entities and additional information about these actors and the link between them. Social network attributes consist of network variables such as the position of the person in the network, interaction with other people in the network, nature of the network; and the variables of the people in the network, relationships with each other, occupation of the network members, and level of closeness to each other (Borgatti, Everett, & Johnson, 2013; Prell, 2011).

Social networks have grown substantially over the last decade. Global internet coverage increased from 17 % in 2005 to 55 % in 2019. As of April 2020, 59% of the global population were active internet users (Clement, 2020; ITU, 2019). In developed countries such as Sweden, the UK, and the US, almost 100% of young people have access to the internet (Jonsson, Bladh, Priebe, & Svedin, 2015). This growth has motivated adolescents to connect or build social networks online and offline. Adolescents use these social networks for various purposes: to communicate with people of similar interest (Hayez, 2009), to post and exchange selfies (Zheng, Ni, & Luo, 2019), to be entertained and communicate with friends via different apps for the purpose of sharing information, ideas, opinions, messages, images, and videos (Eveline A. Crone & Elly A. Konijn, 2018b). Today, adolescent social networks have expanded beyond peers as a result of advanced IT technologies and the creation of various cyber platforms (Lin & Van der Putten, 2015; Sklenarova, Schulz, Schuhmann, Osterheider, & Neutze, 2018). Existing research has shown that these growing online and offline social networks contribute to risky behaviours of adolescents (De Graaf, Verbeek, Van den Borne, & Meijer, 2018; Tozun & Babaoglu, 2018; Thomas W Valente, 2010; Willoughby, Hust, Li, & Couto, 2020).

Social networks and adolescent sexual health research

Social network researcher Thomas W Valente (2010) has suggested that there is no health topic that is not related to the concept of social networks because individuals are embedded in the networks of social relations and interactions (Thomas W Valente, 2010). Indeed, Klovdahl (1985) demonstrated how the HIV outbreak in the 1980s was linked to personal relationships of people in their social networks (Klovdahl, 1985). The social perspectives of people sexual behaviours in general population was considered in the research in early 1990s. In the book of the Social Organization of Sexuality by Laumann et al. (1994), the sexual behaviour of 3,432 people age 18-59 were studied by different factors including social factors such as education, race cand religions, social network and partnering process, homophily among partnerships, the structure of between group contact, and sexual dyad (Laumann, 1994).

In the last decade, researchers have begun to study adolescent health from the perspective of peer influence and social networks on adolescent health behaviours such as smoking (Mercken, Sleddens, de Vries, & Steglich, 2013; Mercken, Snijders, Steglich, & de Vries, 2009; Tucker, De La Haye, Kennedy, Green Jr, & Pollard, 2014) , obesity (Salvy, Howard, Read, & Mele, 2009), alcohol (Huang et al., 2014), and substance abuse (Arulogun, Ogbu, & Dipeolu, 2016; Tucker et al., 2014). In terms of sexual behaviours of adolescents, researchers have focused mainly on how the sexual behaviours of adolescents are influenced by their peers or the use of the internet. The areas of research have included the relationship between (1) the number of SMS per day and having ever had sex (Landry, Gonzales, Wood, & Vyas, 2013), (2) sexting and condom used (Bauermeister, Yeagley, Meanley, & Pingel, 2014), and (3) having home-based peers and sexual behaviour of homeless adolescents (Ali, Amialchuk, & Dwyer, 2011).

In recent years, researchers used an advanced social network analysis approach to explore the effects of social networks on adolescents' sexual behaviours. C. R. Browning, B. Soller, and A. L. Jackson (2015b) applied an eco-network approach (the degree to which neighbourhoods interact) to determine whether neighbourhood enforcement (the tendencies of neighbourhood residents to engage in shared activities within two or more routine activity clusters) is negatively associated with the status of being sexually active in adolescents. E. Fearon et al. (2019) explored the association between tie strength (the degree to which network members interact with each other) and the status of being sexually active in adolescents and found that there was weak evidence that lower friendship density in the network was associated with ever having sex (OR- 0.96, 95% CI 0.93-1, p=0.005). They also found that young women were more likely to report ever having had sex when they perceived that their friends were sexually active. Handebo, Kebede, and Morankar (2018) conducted a similar study investigating social connectedness and sexual behaviours and found that connectedness was inversely related with the risky sexual behaviours.

Rationale of the current research

The original Latin word, 'adolescere' means 'to grow to maturity'. (Kar et al., 2015) Healthy sexual development is a part of adolescent life to bring pleasures and emotional intimacy with partners (Beckmeyer, Herbenick, Fu, Dodge, & Fortenberry, 2021; Saliares, Wilkerson, Sieving, & Brady, 2017). Adolescents' protective sexual behaviours have improved in some parts of the world. The comparison of sexual behaviours of US adolescents aged 15-19 in three periods: 2006-2010 (n=4,662), 2011-2015 (n= 4,134), and 2015-2019 (n= 3,182) found that females reported increases use of any contraceptive

methods from 86% in 2006-2010 to 91% in 2015-2019. Adolescent males reported increased in partners' use of IUDs or implant use (1% in 2011-2015 to 5% in 2015-2019) (Lindberg, Firestein, & Beavin, 2021).

It cannot be denied that sex in adolescents is associated with some adverse health outcomes. Analysis of cross-sectional data from 116,820 adolescents aged 12-15 years participating in the Global School-based Student Health Survey 2009-2016 by WHO showed that there is a positive between had multiple partners (having more than one partner) and increased odds of suicide attempts (pooled OR 1.58) (L. Smith et al., 2020). Moreover, in the analysis of the British birth cohort (5,593 boys and 5,724 girls from the Millennium Cohort Study), adolescents from the categories of "kisser", "touching under clothes", "genital touching" and "all sexual activities" reported significantly more substance use and self-harm attempts compared to adolescents from the "no sexual behaviour" group (Y. Xu, Norton, & Rahman, 2022). The cross-sectional study of 178,667 Korean adolescents found that depression was highly reported in the adolescents who experienced sexual intercourse than those who did not do so (adjusted odd rations = 1.71, 95% CI = 1.59- 1.83) (Kim, Jeong, Jang, Kim, & Park, 2021).

Social networks of adolescents mean a lot to the health behaviours of adolescents including sexual behaviours. Social networks can benefit adolescents by allowing them to extend their network beyond their families, engage new people in their online and offline social networks, find their sexual identity, search for like-minded people and keep in touch with existing networks (K. R. Mitchell et al., 2021; Montgomery et al., 2020). On the other hand, social networks can have adverse effects by exposing adolescents to certain risky sexual behaviours, such as promoting early first sexual exposures, having multiple sexual partners, sex without condom, and unwanted sex, depending on the network in which they are embedded (Bhushan et al., 2022; Borraccino et al., 2020; Darfour-Oduro & Grigsby-Toussaint, 2022; Isaksson, Westermark, Koposov, Stickley, & Ruchkin, 2021).

The social network the adolescents embedded shape the sexual behaviour of adolescents. The study of 15-20 years adolescents (N =2990) in 176 rural Hondarus found that there is significant association between a girl's risk of adolescent childbirth and both a social contacts' adolescent childbirth and the village proportion of women who had had an adolescent childbirth (Shakya, Darmstadt, Barker, Weeks, & Christakis, 2020). Adolescents also take account to the perception of social environment on their reproductive health decisions. The study of 200 adolescents in Haiti showed that adolescents reported their concern to the social perceptions on their sexual behaviours, 42% were concerned about parental approval of birth control and 29% were concerned that their friends might think they were looking for sex (Masonbrink et al., 2023).

There are also conflicting findings of social networks and adolescents. For example, the study of 189,918 adolescents in Italy found that adolescents with high social support performed healthy sexual behaviours such as more likely to use condom (Borraccino et al., 2020) while the study of 22,067 adolescent girls from Global School-based Student Health Survey national data 2003-2015 of sub-Saharan Africa found that adolescents who felt supported by their peers were more likely to have higher number of sexual partners than those who did not feel supported by peers (Darfour-Oduro & Grigsby-Toussaint, 2022).

Research on healthy sexual development in adolescents has been limited or lacks focus, particularly in the light of its growing complexity due to the advancement of IT technologies and online social networks (Bundy et al., 2018). Without understainding the evolving nature of adolescents sexual health issues in the information technology era, traditional interventions for the adolescents sexual health might not be impactful. Although research has been called to investigate the effects of social networks on sexual health (Kwan, 2020; Robinson, Trent, Ellen, & Matson, 2020; Vangeel, Eggermont,

& Vandenbosch, 2020), empirical literature remains limited because the social network is an emerging issue in the context of adolescent health, and social network analysis methods are still developing.

Therefore, an examination of the relationship between social networks and sexual behaviour of adolescents is timely and fills an important gap in the existing literature. My research aims to map the pathways in which young people's use of social networks could support or undermine their healthy sexual development using the proper social network analysis methodology and UCINET software.

Structure of the thesis

This thesis examines the relationship between the variables of social networks online and offline, the variables of people in the adolescents' networks, and the sexual behaviours of the adolescent participants.

These studies are to test (1) the social networks and age of first sexual exposure in adolescents; (2) the variables of the social networks and sexual behaviours of adolescents at three time points (baseline survey, midline survey, and end-line survey); (3) the social network variables and sexual behaviours of adolescents across three time points; (4) the variables of people in the networks and sexual behaviours of adolescents at three time points and (5) the variables of people in the networks and sexual behaviours of adolescents across three time points. Simple logistic regression models, multiple logistic regression models, generalized estimating equation (GEE) models, and meta-analysis were used to analyse the data.

The variables of social networks of interest in this study include: ego density (percentage of all possible ties in a person's network that are actually present), average tie strength (combination of the amount of time and emotional intensity between two people), degree centrality (number of contacts a person has in the network), betweenness centrality (frequency with which a person falls along the shortest path between two other people in a network), efficiency (total number of nonredundant people reached by the primary contact) and constraint (the length someone has to spend time and energy to connect non-redundant contact in the networks).

The thesis is structured as follows: Chapters 2 provides the thesis context by explaining healthy sexual development in adolescence, adolescence and social networks, social network analysis for adolescent's sexual behaviours, and influence of people in the networks on the sexual behaviours of adolescents. Chapter 3 describes the methodologies employed in the social network analysis, logistic regression models, and GEE models. Chapters 4 present the studies and their findings individually. Chapter 5 extends the discussion of these findings drawing on relevant theories from previous research, to arrive at the implications of a social network perspective for adolescents' healthy sexual development.

2. Literature review

2.1. Adolescence and healthy sexual development

Adolescent health

Historically, the health of adolescents has been neglected for a long time as the mortality rate in this age group is low compared to other age groups (Patton et al., 2018). However, the health status of adolescents is of paramount importance. The second Lancet series on adolescent health concluded that 'Failure to invest in the health of the largest generation of adolescents in history jeopardises earlier investments in maternal and child health, erodes future quality and length of life, and escalates suffering, inequality, and social instability' (Patton et al., 2016a).

Bundy (2018) suggested that the current health policy makers' approach to focus on health during the first 1,000 days of life is not sufficient. The focus should also extend to the later phases of life: the middle childhood growth and consolidation phase (5-9 years) when infection and malnutrition could slow growth, the growth spurt phase (10-14 years) when good diet and health care are essential for substantial changes in the body, and the growth and consolidation phase of adolescents (15-19 years) when brain maturation and intense social engagement occur (Bundy et al., 2018).

During the transition from childhood to adulthood, adolescents become more self-aware and self-reflective. However, the capacity for multidimensional thinking in a strategic manner is still developing at this stage. Recent studies have revealed that the prefrontal cortex undergoes dramatic changes in puberty and adolescents. In the human brain, the cerebral cortex is a critical structure for perception, thinking, and reasoning. Since the frontal cortex is still developing with synapses pruning and myelination of the axons, it indicates that the executive function of adolescents is not as well functioning as in adults (Blakemore & Choudhury, 2006).

In the 21st century, adolescents are facing new challenges in terms of health and well-being. Mental disorders have reached historically high levels in adolescents worldwide (Suen, Chan, & Wong, 2020; Tordon et al., 2019; Verelst et al., 2020; Walsh et al., 2020; Zouini, Sfendla, Ahlstrom, Senhaji, & Kerekes, 2019). Alcohol (Perkins, Varlinskaya, & Deak, 2019; Peterson et al., 2020; Singkorn et al., 2019; Wilhite & Fromme, 2019) and substance use among adolescents (Windle, 2020; W. Xu et al., 2020; Zilberman, Yadid, Efrati, & Rassovsky, 2020) also continues to increase in some countries. Mental illness in adolescents is related to high-risk sexual behaviours including multiple sexual partners, inconsistent use of condom, and lack of contraception (Olmsted et al., 2022). Early marriage, limited education, and early exposure to economic and social hardship are things that made adolescents vulnerable (Temple-Smith et al., 2015). Biological, cognitive, behaviours, and socioeconomic risk factors could contribute to poor sexual health outcomes (Slater & Robinson, 2014).

Young people live across the world with different social, cultural and economic backgrounds, and therefore have different challenges to cope with as they experience the changes associated with puberty and beyond. Half of adolescents live in multi-burden countries with high levels of adolescents' health problems such as HIV and infectious diseases, undernutrition, poor sexual and reproductive health, injury and violence, and non-communicable diseases. These countries also have an unmet need for contraception, especially in unmarried sexually active adolescents (Le Linh & Blum, 2009; D. Y. Lee, Moon, Lee, Suh, & Choi, 2012; Patton et al., 2016b; J. Smith, 2020; M.-L. Wong et al., 2009). Furthermore, one in eight adolescents living in injury-excessive countries continuously experience high levels of violence, with unintended pregnancies and births (Patton et al., 2018; Patton et al., 2016b).

There is also evidence of health inequalities for socially and economically marginalized adolescents such as lesbian, gay, bisexual or transgender (LGBT) (Juster, Hatzenbuehler, Salway, Figueroa, & DuBois, 2019; Lin & Van der Putten, 2015; Pachankis et al., 2017; Ybarra & Mitchell, 2014; L. E. Young, Fujimoto, & Schneider, 2018a) and homeless youth (Kamke, Widman, & Haskett, 2020; Patton et al., 2016b; E. Rice, Monro, Barman-Adhikari, & Young, 2010; Tucker et al., 2012; Tyler, 2008). Sexual minority adolescents, meaning either youth that reported being heterosexual but had sex with same sex partners or bisexuals with both partners of both sexes, were at higher risk of having sex with unfamiliar partners and having sex while using substances (Norris et al., 2019; Paul Poteat, Russell, & Dewaele, 2019), and more sexual partners (Norris et al., 2019). They also face potential relationship harm resulting from safer sexual negotiation (Norris et al., 2019), and negative sexual health outcomes relative to their heterosexual peers(Newcomb, Feinstein, Matson, Macapagal, & Mustanski, 2018). Homeless adolescents are at enormous risk of human immunodeficiency virus (HIV) infection, sexually transmissible infections (STI), and unplanned pregnancy (Kamke et al., 2020).

Adolescents do not fully benefit from sexual health-related rights, even though these are in place in legal frameworks. For example, the WHO and UN have stated that adolescents have the right to comprehensive sexual education. However, comprehensive sexual health education models for adolescents are still developing. The school-based initiatives model launched in Chile recommended that effective and ongoing collaboration between health staff and teachers for the delivery of integrative approach to sexual and reproductive health promotion is needed (Obach et al., 2022). In countries with conservative social norms like Iran, sexual health education for adolescents program suggested many barries such as lack of clear policy, cultural heterogeneity, weakness of communication, concerns of judges by the community, and school inadequacy (Askari, Mirzaiinajmabadi, Saeedy Rezvani, & Asgharinekah, 2020).

Discussion with adolescents about sexual and reproductive health is also challenging topic for health care providers. As a result, many adolescents and young adults do not receive adequate and comprehensive sexual education (Roden, Schmidt, & Holland-Hall, 2020). Furthermore, some customary or religious laws, cultural, and gender norms still discourage adolescents' access to assets for their reproductive health, such as contraception (Leekuan, Kane, & Sukwong, 2021; Patton et al., 2018; Patton et al., 2016b; J. Smith, 2020). Moreover, sexual and reproductive health services are needed to meet the needs of adolescents and be innovative such as mobile outreach service, flexible hours (P. Smith et al., 2018) and accurate and comprehensive (Kemigisha et al., 2018).

The new development of social media has brought both opportunities and risks. Social media provided many benefits, such as being a good sexual health promotion tool (Patterson, Hilton, Flowers, & McDaid, 2019; Reynolds, Sutherland, & Palacios, 2019; Scull, Kupersmidt, Malik, & Keefe, 2018; Teadt, Burns, Montgomery, & Darbes, 2020; von Rosen, von Rosen, Tinnemann, & Muller-Riemenschneider, 2017), and a broader dissemination of HIV and STD prevention messages (Javidi et al., 2021), and evidence-based information on contraception to help adolescents make informed decision about contraception (Leekuan et al., 2021; J. Smith, 2020). It has also been a new communication tool for developing sexual relationships, helping with dating and courtship rituals, providing opportunities for isolated adolescents to engage with others (Temple-Smith et al., 2015). However, with the rapid development and engagement with online social networks which is overlapped with offline social networks, health-related risks emerge notably in adolescents (Patton et al., 2018).

Sexual behaviours during adolescence

Adolescence is a critical time for sexuality (Ebert, 2015), sexual health is an integral part of overall health of adolescents (Temple-Smith et al., 2015). Every adolescent should have the opportunity to

experience safe, enjoyable sex, free of coercion, discrimination, and violence (Roulet, Piccand, & Jacot-Guillarmod, 2022). Sexuality in adolescents should not be considered a problematic issue. Mentally and physically safe sex can positively support adolescents' development to be independent, socially competent, and self-esteemed even though early sex happening in inappropriate contexts could have negative consequences (Temple-Smith et al., 2015).

In recent decades, the number of sexually active adolescents has increased worldwide (Brooks-Gunn & Furstenberg Jr, 1989) and in Australia (Christopher Fisher, 2019; C. M. Fisher et al., 2020). In a British study that interviewed adolescents aged 15-19 years in the early 1960s, only 20 percent of boys and 12 percent of girls were sexually active. Studies in the later 1980s and 1990s showed that 35-50 percent of teenagers had sexual experience at the end of high school (Temple-Smith et al., 2015). According to the national survey of secondary students and sexual health Australia 2018, approximately half of the students reported having oral sex both giving (52%) and receiving (51.4%), vaginal sex (44.4%) and anal sex (12.6%) (Ezer, Kerr, Fisher, Heywood, & Lucke, 2019). These figures showed upward trend in the most recently published national survey of secondary students and sexual health Australia 2021, 58.5% had experienced oral sex, 52.0% had experienced vaginal sex and 15.0% had experienced anal sex (Power, Kauer, Fisher, Bellamy, & Bourne, 2021) (Power et al., 2021).

This could be due to the fact that social norms for adolescent sexuality have changed remarkably in the last two to three decades. Darling, Kallen, and VanDusen (1984) identified three historical periods of the Europe between 1900-1980 with different sexual standards. The first, 1900-1950s, was the period of the double standard, which accepted sexual activity for boys but prohibited it for girls. The second one, 1950-1970, premarital sex was socially acceptable for young people if it occurred in a love relationship that was a prelude to marriage. The sexual revolution of 1960-1970s resulted in more permissive attitudes towards sexuality and more respect for personal fulfillment, therefore a lessening of prohibition of premarital sex. The third one, after the 1970s, people believed that it is unrealistic to expect young people to abstain from sexual activity until their late twenties. Since then, sex outside of a romantic relationship has been tolerated (Darling, 1984; Furman, 1999).

In recent decades, adolescent sexual relationships have become more varied than previously. Casual encounters, assisted by social networks, made changes in the sexual lives of adolescents. In addition to regular dating, online assisted hooking has become a part of their dating practice. Hooking up is finding a casual partner probably that may tend to a regular partner, with little or no expectation for future romantic commitment as regular dating does (Fortunato, Young, Boyd, & Fons, 2010; Garcia et al., 2019; Temple-Smith et al., 2015).

Healthy sexual developments of adolescents

Sexual health is beyond the freedom from diseases, as WHO developed a definition that covers the quality of healthy sexual relationships, having pleasure and absence of discomfort. "Sexual health is a state of physical, emotional, mental, and social wellbeing related to sexuality; it is not merely the absence of disease, dysfunction, or infirmity. Sexual health requires a positive and respectful approach to sexuality and sexual relationships, as well as the possibility of having pleasant and safe sexual experiences, free of coercion, discrimination, and violence. To achieve and maintain sexual health, the sexual rights of all persons must be respected, protected and fulfilled" (WHO, 2017).

In the lives of adolescents, the sexual urge is mixed with other aspects of life. It is essential that they have the capacity to combine their sexual desires with a positive self-identity. Therefore, it requires maintaining a sense of self-worth while trying to achieve intimate relationship satisfaction. The wrong

choice could lead to unwanted outcomes such as anxiety, guilt, and a sense of unworthiness. Therefore, addressing these sexual issues with a satisfactory sense of their own identity was not an easy task for adolescents. (Temple-Smith et al., 2015).

The third National Survey of Attitudes and Lifestyles for residences of Britain, carried out in 2010-2012 in which 2825 sexually experienced 17-24 years old participated, and asked about the level of sexual competence which included consent, autonomy, contraceptive use and readiness, and researchers concluded a substantial proportion of young people became sexually active under the circumstances of incompatible with sexual health (Melissa, Lynda, George, & Kaye, 2019). Since adolescent sexuality is complex and intertwines biological, social, sexual, and cultural factors, it should be approached comprehensively to have healthy sexual development (Finer, 2007). There have been many suggestions to change the view of adolescent health as a problematic issue to an approach that emphasizes positive sexual development which can imply for general wellbeing of adolescents over the course of life (Halpern, 2010).

Largerberg (2001) argued that 'the sexual development of normal children is neither fully explored nor understood.', A group of Australian researchers from various disciplines conducted a review study, discussed their findings, and jointly developed a framework for researching healthy sexual development (McKee et al., 2010) though it was a biopsychosocial process with a vast array of inputs that cannot be distilled done to a single truth. The domains identified in the framework consisted of freedom from unwanted activity; an understanding of consent; education on biological aspects; understanding of safety; relationship skills; agency; lifelong learning; resilience; open communication; sex not being aggressive, coercive or joyless; self-acceptance; awareness and acceptance that sex is pleasurable; understanding of parental and social values; awareness of public/private boundaries; and competence in mediated sexuality (McKee et al., 2010).

Freedom from unwanted activity means that healthy sexual development should take place in a context in which adolescents are protected from unwanted sexual activity. One should have an understanding of consent, know what ethical conduct means, and accept that healthy sexuality should not be coercive. Adolescents should understand the nature of consent and the ethics of human relationships. Furthermore, adolescents should have an education on the biological aspects of sexual practice that covers accurate information about how their bodies work. Researchers discovered that in the absence of adequate and systematic sex education for children, they create their own explanation for biological and sexual processes, as far as they understand (McKee et al., 2010).

Understanding safety means that children learn about safe sex practice, such as physical safety and safety from sexually transmitted diseases. Relationship skills consist of asking for what they want or like in an assertive way in sexual relationships. Agency means controlling their own sexuality and controlling the one who takes sexual pleasure from their bodies. They should understand their rights and their responsibility for their own decisions in terms of sex, as well as to be confident in resisting peer pressure. Lifelong learning means that children are naturally curious about their bodies from birth. They touch their genitals, masturbate, and play sex games with other children from an early age. These behaviours are normal and not harmful to subsequent sexual development (McKee et al., 2010).

Resilience means that adolescents must develop the ability to turn bad sexual experiences into opportunities to learn rather than breaking down. Open communication consists of communication between adults and children in both directions. Adolescents should receive age-appropriate sex information, especially to give honest answers to the questions they have about sex. Sexual development should be free of aggressiveness and coercion. They should be aware of the distinction

between healthy and unhealthy sexual development. Healthy sexual development is fun, playful, and lighthearted, while unhealthy one is aggressive, coercive, or joyless (McKee et al., 2010).

Self-acceptance refers to developing a positive attitude toward your sexual identity and developing a positive concept about your body. Awareness and acceptance that sex is pleasant means that children should understand that it is not shameful to enjoy sex. Internalizing this concept helps them to enjoy satisfying sex and develop quality sexual relationships. Adolescents should also understand social and parental values about sexuality. Understanding these values will allow them to make informed decisions about their own sexuality. They should also be aware of public / private boundaries, such as values about sexuality, privacy, and public behaviours, to understand how to negotiate these boundaries (McKee et al., 2010).

Risky sexual behaviours

The risky sexual behaviours previous researches found out are 1) no use of condom during sex (Sserwanja, Mwamba, Poon, & Kim, 2023; Thepthien & Celyn, 2022) (Isaksson et al., 2021; Thomas, Colich, McLaughlin, & Sumner, 2023), having multiple sexual partners (more than one partner) (Fortenberry, 2013; Sserwanja et al., 2023; Thepthien & Celyn, 2022; Thomas et al., 2023), early age at first sex (Sserwanja et al., 2023; Thomas et al., 2023), substance use during sexual encounters (Isaksson et al., 2021), translational sex or having sex in exchange for cash or in-kind compensation (Sserwanja et al., 2023; Thepthien & Celyn, 2022) and having sex without consent (Thepthien & Celyn, 2022).

Poor sexual and reproductive health outcomes of adolescents are still happening in the world, even though it should not as the result of the risky sexual behaviours of adolescents. According to data from sub-Saharan African and Latin American countries, 10-15% of 15-24 years old reported having their first sex experience before the age of 15 (Patton et al., 2016b). In the United States, approximately 1 in 5 new HIV diagnoses occurred in individuals aged 13-24 years. Rates of sexually transmitted infections are increasing among individuals aged 15-24 years (Agwu, 2020). The 2015 Dane Country Youth Assessment data from the US showed that a significant proportion of adolescents engaged in sex with unfamiliar partners, sex under substance use, sex without protection, and decline to STI testing (Paul Poteat et al., 2019). Lower contraceptive use in the last sex and less discussion about sexually transmitted infection and birth control pills with their partners were still reported in adolescents in the US (Thompson et al., 2020). In Australia, the percentage of unwanted sexual activity in sexually active adolescents increased from 25.8% in 2002 to 33.8% in 2018 (Christopher M Fisher, 2019).

Risky sexual behaviours lead to unhealthy consequences in adolescents. Risky sexual behaviours can result in sexually transmitted diseases including HIV in adolescents (Akumiah, Suglo, & Sebire, 2020; Bukenya et al., 2020a; Kar et al., 2015; Vasilenko, 2022) . Early sexual exposure leads to unintended pregnancies as an adverse consequence on the reproductive health of adolescents if contraceptive measures are not taken (Akumiah et al., 2020; Bukenya et al., 2020a; Isaksson et al., 2021; Kar et al., 2015). The National Longitudinal Study of Adolescent to Adult Health (Add Health) also found that early sexual behaviors predicts higher rates of sexually transmitted infection and pregnancy in young adults (Vasilenko, 2022).

Risky sexual behaviours are more burdened by other factors in developing countries. In developing countries, the use of contraception is still low and, therefore, teenage pregnancy and adolescent parenthood are still happening (Kar et al., 2015). Unwanted pregnancy leads to unsafe abortions and

contemplate suicide (Miller et al., 2021). In addition to risky sexual behaviours, other factors such as partner violence, gender inequitable norms, low relationship power, and inadequate communication about STI prevention also contribute to adolescent motherhood (Bhushan et al., 2022). Level of literacy, socioeconomic status, knowledge about contraception are also influencing adolescents to have pregnancy (Mohammed, 2023).

Risky sexual behaviours do not limit to risk lifestyle, these extend to other risk behaviours such as poor school performance, substance use, alcohol use, violence involvement, and poor health outcome at the later age after adolescence (Bhushan et al., 2022; Sharma & Vishwakarma, 2020). Researchers found that young people involved in unsafe sexual activities also engaged in other unhealthy behaviours such as smoking, alcohol consumption, drug use, and were associated with each other (S. E. Baumgartner, P. M. Valkenburg, & J. Peter, 2010; Van Hoorn, Crone, & Van Leijenhorst, 2017; J. M. van Oosten, J. Peter, & L. Vandenbosch, 2017; J. M. F. van Oosten, J. Peter, & L. Vandenbosch, 2017; Vanden Abeele, Van Cleemput, & Vandebosch, 2017; Vandenbosch, Beyens, Vangeel, & Eggermont, 2016; Whiteley et al., 2011; Widman, Choukas-Bradley, Helms, & Prinstein, 2016; Wolak, Finkelhor, & Mitchell, 2008; Ybarra & Mitchell, 2014; S. D. Young & Rice, 2011; Zou et al., 2010). The study of 6,167

high school and vocational school students from Thailand reported that risky sexual behaviours are associated with other risk factors: smoking, cannabis use, gambling, and history of child abuse (Thepthien & Celyn, 2022). The study of 1,200 adolescents reported that those who used substance or alcohol during sex were more likely to have unintended pregnancy (Ngoc Do et al., 2020).

Timing of first sexual exposure

The age of first vaginal sex is a proxy indicator of the sexual behaviours of adolescents. The definition of the early age of first vaginal sex varies between regions and studies. A study from the US defined the early age of having one's first sexual experiences as below 13 years of age (Kaestle, Halpern, Miller, & Ford, 2005) while others defined the early age of one's first vaginal sex as below 15 years of age (B. M. Magnusson, Masho, & Lapane, 2011, 2012).

The first vaginal sex was an important milestone for adolescents. The first sex could occur as expected or not in adolescents. First sex experience could fail to meet expectations even though adolescents prepared for that experience through childhood sexual experimentation like masturbation or other explorations like discussion with patients. The response to their first sex would be different. While some regret the first sexual experience because they should have waited longer to have the right timing and right person, some people said their first sexual experience was well-timed, wanted and fun (Furman, 1999; Temple-Smith et al., 2015).

The risk associated with early sexual exposure was not identical in male and female adolescents. A study carried out in Croatia with 773 adolescent boys and 857 adolescent girls described the risks associated with the early sexual experience specified by sex. The early sexual experience in boys was associated with negative behaviours such as alcohol use, marijuana use, physical fights, and bullying others, while in girls it was associated with dissatisfaction with their life, communication with parents, and reported physical health and psychosomatic symptoms. Both genders of adolescents reported poor school achievement (Kuzman, Simetin, & Franelic, 2007).

Sexual initiation too early has an adverse psychological effect in both male and female adolescents. Some described considerable ambiguity in their decisions about having their first sexual experiences. Some regret their decision about early sexual initiation, some felt sad for having had sexual relationships early due to the pressure from their partner or the perception that their friends already engaged in sex (Kuzman et al., 2007; Temple-Smith et al., 2015). An early age of the first vaginal sex was associated with internalizing (eg, anxious, depressed) and externalizing (e.g. aggressive) behaviour problems in childhood (S. R. Skinner et al., 2015). The age of first sex is also a factor in German male adolescents to have anxiety if that age is not similar to the age they believe to be the appropriate age of first sexual exposure (Komlenac, Pittl, Perkhofer, Tucek, & Hochleitner, 2022).

Researchers see the early age of the first vaginal sex as an undermining factor for healthy sexual development in adolescents. Early sexual debut was found to be associated with a greater number of partners (Coker et al., 1994; J. S. Santelli, N. D. Brener, R. Lowry, A. Bhatt, & L. S. Zabin, 1998), concurrency of sexual partners and serial monogamies with periods of 1-3 months between partners (Brianna M. Magnusson, Nield, & Lapane, 2015). Girls who had first sexual experiences at an early age were more likely to report having sex under the influence of alcohol or drugs (J. S. Santelli et al., 1998) and a higher chance of facing gender-based violence and victimization (Halpern, Spriggs, Martin, & Kupper, 2009).

Adolescents who initiated sexual activity at an early age were also more likely to show a gap in contraceptive use (adjusted odd ratio: 1.93, 95% CI: 1.23-3) (B. M. Magnusson et al., 2012), increasing the chance of pregnancies (Coker et al., 1994), and possibly resulting in multiple unintended pregnancies (adjusted OR 6.96, 95% CI 4.26, 11.39) (B. M. Magnusson et al., 2011). In more than 120,000 pregnancies in girls aged 10-24 years in a Multi-country Survey of Maternal and Child Health

of WHO, those who gave birth before 15 years were at higher risk of eclampsia and puerperal infection. Their babies had a higher risk of eclampsia and puerperal infection. Their babies had higher rates of low birth weight, preterm delivery, and severe neonatal conditions. Similarly, in a pooled analysis of 19,403 offspring from birth cohorts in Brazil, Guatemala, India, the Philippines and South Africa, giving birth before the age of 19 predicted low birth, weight, preterm birth and stunting of offspring, and those associations were strongest in the youngest mothers (Patton et al., 2018).

Even in high-income countries, maternal and offspring outcomes are also poorer in those giving birth before 15 years of age, with greater infant death, stillbirth, intrauterine growth restriction, and preterm birth. Teenage childbearing is often unplanned and is associated with partnership instability, creates a greater likelihood of single parenthood, greater poverty, and less parental education contributing to poor child outcomes. Even small delays of 6-18 months in the transition to motherhood independently predicted offspring test scores for reading and mathematics, which in turn, are in turn predictive of educational attainment and eventual earnings (Patton et al., 2018).

Temple-Smith (2015) suggested that the age of sexual initiation is a subject with conflicting evidence. There is a diverse opinion on an average age for loss of virginity since there are differences in individual, gender, cultural group, and neighborhood group. Studies from different countries suggested a variety of levels of sexual experience for similar-aged young people from diverse racial, religious, social and ethnic groups. The ideal age for the loss of virginity also depends on the maturity (Temple-Smith et al., 2015).

The mean age of first sexual experiences in adolescents in Australia are exposure to online pornography (13.6 years), masturbation (13.7 years), kissed (14.6 years), touched on genitals by a partner (14.9 years), touched a partner's genitals (15 years), gave oral sex (15.1 years), received oral sex (15.2 years), vaginal sex (15.3 years), and anal sex (15.6 years) (Power et al., 2021). The age of initiation of sex and number of sexual partners in transgender adolescents are similar to those observed in cisgender adolescents according to the US research which consisted of 1,223 adolescents those identifying as trans boys, trans girls, nonbinary and questioning their gender identity (age range 14-18 years) (Maheux, Zhou, Thoma, Salk, & Choukas-Bradley, 2021). A study of 465 justice involved young people from Australia, aged between 14-17 years, reported 76% reported having ever had sex, with the median age of sexual initiation 14 years (Yap et al., 2020) .

Having multiple sexual partners

Adolescents engage in a wide variety of sexual behaviour and have more partners than before. Both formal and casual relationships help adolescents explore sexuality. The successes and failures, pleasures, and disappointments of these relationships assist young people to acquire skills in intimacy which are essential for the adaptation of long-term partnerships (Temple-Smith et al., 2015).

In the Australian National Report on Adolescent Sexual Health 2018, half of the respondents had one sexual partner in the last year, while 15.5% had two partners, 19% had more than three partners and 3.9% had no sex in the last year (Christopher M Fisher, 2019). In a developing country with conservative norms like Thailand, eight percent of the male teenagers reported having more than one sexual partner in the last three months (Pinyopornpanish et al., 2017). In a study of five sub-Sahara African countries, the prevalence of having sex with multiple partners in adolescents was 20.9% (3,240) (Shayo & Kalomo, 2019). The proportion of having multiple sexual partners increased over the age of adolescents, the highest level was after age 20 in adolescents (Vasilenko & Lanza, 2014).

Having multiple sexual partners was associated with other risky health behaviours such as smoking, alcohol, substance use (Shayo & Kalomo, 2019; Vasilenko & Lanza, 2014) and alcohol use (John S. Santelli, Nancy D. Brener, Richard Lowry, Amita Bhatt, & Laurie S. Zabin, 1998; Shayo & Kalomo, 2019) and sexually transmitted diseases (Hensel & O'Sullivan, 2022). Having multiple sexual partners is more likely to have transactional sex 5.2 times (adjusting OR; CI: 2.1-12.9) (Chiang et al., 2021).

Unwanted sex

One of the components of healthy sexual development of adolescents is freedom from unwanted sex. Unwanted sex consists of different terminologies unwanted sex (Temple-Smith et al., 2015), intimate partner violence (Vyas, 2022), adolescent relationship abuse (Hill et al., 2022), and reproductive coercion (PettyJohn, Reid, Miller, Bogen, & McCauley, 2021). Adolescence is also a critical time to prevent violence in intimate relationships (Bush, 2020; DeLong et al., 2020; Vyas, 2022). Adolescents experienced unwanted sexual activities either during their first sexual exposure or during their routine sexual activities (Temple-Smith et al., 2015).

Some young people experienced involuntary sexual initiation in their first sexual experience. The most common reasons are they were under the influence of too much alcohol, drug, or their partner wanted them to do it (Temple-Smith et al., 2015). A qualitative study of girls aged 14-19 years explored some reasons why adolescents do not feel good about their first sexual experience. She found that some teenage girls who had first vaginal sex while not ready yet, in an early age, felt regret and disappointment for that experience. She concluded that the degree of personal control over the situation was the main reason for those circumstances (R. S. Skinner, Smith, Fenwick, Fyfe, & Hendriks, 2008).

Fisher (2019) suggested that a quarter of Australian sexually active students (28.4%) experienced unwanted sex at once, comparatively higher in young women 36.8% and 15.9% in males in their sexual experiences (Christopher M Fisher, 2019). Although it is possible for more female adolescents to face unwanted sex than male counterparts due to the dynamics of gender power dynamics, it can also be possible for a young man to be the recipient of unwanted sex (Temple-Smith et al., 2015).

Reasons to have unwanted sex were that the respondent person being too drunk at that time, the respondent person being too high at that time, the respondent person's partner thinking that the person should do it, the respondent person's friend thinking that the person should do it, the respondent person was scared (Christopher M Fisher, 2019). Unwanted sex occurred in adolescents when one feared that the partner would get angry if sex is denied. Factors triggering unwanted sex were having a baby with a partner, lack of sexual control, less condom use, substance use and low quality of relationship (Blythe, Fortenberry, Temkit, Tu, & Orr, 2006). Adolescents with high self-efficacy and those who spoke more frequently with their parents about sexual issues were more likely to refuse unwanted sex with their partners (Sionean et al., 2002).

Intimate partner violence was associated with poor health and social outcomes (Rome & Miller, 2020), lifetime pregnancy and unwanted pregnancies (PettyJohn et al., 2021), pregnancy termination (Ahinkorah, 2021) , and psychological distress (Mthembu, Mabaso, Reis, Zuma, & Zungu, 2021), depression and anxiety (Brar et al., 2020; Marcal, 2021) . Early marriage and adolescent pregnancies are also associated with intimate partner violence and are more vulnerable to anxiety and depressive symptoms (Sezgin & Punamaki, 2020). Intimate partner violence was associated with adolescents from households of low socioeconomic status (Mthembu et al., 2021). Resilience to violence by

intimate partners was found in adolescent girls with more equitable gender norms, higher social support, and hazardous drinking (Kuo, LoVette, Slingers, & Mathews, 2021).

Adolescent relationship abuse (ARA) has negative consequences for adolescent girls. The research of 246 female-identified adolescents found that ARA was more likely to report in those who were sexual minority adolescents, with less educated heads of household, and less equitable gender attitudes (Hill et al., 2022). Reproductive coercion in adolescents was associated with having sex under alcohol or drugs, having sex with a male partner 5 years or older (PettyJohn et al., 2021).

Use of condoms

The risk of unplanned or unwanted pregnancies is still a concern globally along with the increased sexual activity of adolescents. An estimated 22 million unsafe abortions occur annually worldwide. Among them, 15% were girls under 20 years of age. Young girls face a high risk of abortion and are more likely to terminate pregnancy compared to those over 25 years of age, and are more likely to terminate pregnancy after the first trimester and are more likely to use unregulated providers (Patton et al., 2016b).

The emergence of emergency contraception has provided more options for adolescents in developed countries. The availability of emergency contraception and expansive emergency contraception policies reduced the birth rate according to the US cohort study of adolescents aged 15-19 years from 2000-2014 (J. M. Wells, Shi, Bonny, & Leonard, 2022). However, misunderstandings in the safety of emergency contraception are still present in adolescents (Williams, Jauk, Szychowski, & Arbuckle, 2021).

A high unmet need for contraception is ongoing among young adolescents from developing countries (Finer, 2007; Hindin & Kalamar, 2017) and young women aged 15-24 years in sub-Saharan African countries (Ahinkorah, 2020; Patton et al., 2016b). Adolescents from multi-burden countries, condom use was below 50%, while reportedly having two or more partners in the past year (Patton et al., 2016b). Approximately three-quarters of adolescentt girls from low and middle income backgrounds did not use contraception, and resulted an unintended pregnancy according to the demographic and health survey of 35 low and middle-income countries consisting of 2,173 girls aged 15-19 years with the current unintended pregnancy (Bellizzi, Palestra, & Pichierri, 2020).

There are several reasons why adolescents do not use contraception. One reason might be the decision about contraception due to the sporadic nature of adolescent sexual activity. Adolescent sexual activity is more likely to be inconsistent, and therefore making a choice for contraception is difficult, especially for regular pills or intrauterine devices (Temple-Smith et al., 2015). Lack of awareness of contraception, lack of control of contraception uses, and gender dynamics influenced the demand for contraception and decision making for prevention of pregnancy in adolescents from developing countries such as Thailand (Leekuan et al., 2021).

There is also evidence that adolescents are still ignoring contraceptive-related health messages. This is happening in developing countries and countries with a significant impact of poverty and lack of knowledge (Patton et al., 2016b). Some adolescents lack condoms due to the influence of situational factors such as high arousal, alcohol and drug use or partner reluctance (Temple-Smith et al., 2015), and low gender equitable attitudes (Hill et al., 2022), and partner did not prefer to use a condom (Govender, Naidoo, & Taylor, 2020).

The national surveys of secondary students and sexual health Australia showed that the condom use of adolescents has increased. In 2018, the number of students who applied condoms used in the last year and the last sexual encounter was 62.2% and 56.9%, respectively (Christopher M Fisher, 2019). It increased in the survey of the following year. Of the Australian sexually active students, condoms were used by 78.1% of male and 77.5% of females at first sexual experience and by 65.1% of male and 58.6% of female at their recent sexual experience, and 91.6% of male and 92.3% of female used some form of contraception at most recent sexual experience (C. M. Fisher et al., 2020).

2.2 Adolescence and social networks

Online and offline social networks of adolescents

Social network is defined as 'a pattern of friendship, advice, communication, or support' between individuals or groups of people within a social system (Thomas W Valente, 2010). Social networks are composed of various persons who have a common goal, interest, or need (Landherr, Friedl, & Heidemann, 2010). There are a variety of social networks such as family networks, socializing networks, career advice networks, emotional support networks and home care networks (Prell, 2011). Bogatti (2009) denoted that 'one of the most potent ideas in social science is the notion that individuals are embedded in thick webs of social relations and interactions' (Thomas W Valente, 2010).

The habit of social networking was informal in the past in the form of offline networks, talking to friends, gossiping, and checking on the health of a friend's well-being, showing pictures, and watching a neighbour's home video. However, it has transformed into online social networking when social media platforms were introduced. As a result of this innovation, information sharing has advanced into long-lasting private and public communications (Dijck, 2013). An online social network is a network that uses the infrastructure of the internet in order to offer identity management, relationship management, profile visualization, and networking. (Landherr et al., 2010). Variables of someone, such as sex, age, and educational background, can influence their social networks (Thomas W Valente, 2010). These web-based services, called social network sites (SNSs), provide individuals with the opportunity to create a public or semi-public profile within their bounded system, to have online chat with whom they share a connection, to view the list of connections, and to extend connections within the system (boyd & Ellison, 2007). Furthermore, online communities, also called virtual communities, take care of collective welfare, interactions with one another, mediating public discussion, sharing feelings, and building relationships among network users (Cao, Basoglu, Sheng, & Lowry, 2015).

Adolescents grow up with digital media devices such as tablets and smartphones (Eveline A. Crone & Elly A. Konijn, 2018a). Most media are available on portable mobile devices; therefore, these devices have became an integrated part of the world (E. A. Crone & E. A. Konijn, 2018). The internet, smart phones, and social networks provide adolescents with a 24/7 connection with others, including very young adolescents (Sklenarova et al., 2018). They live in the social media world not only for their entertainment but also for communication with others via WhatsApp, Zoom, Facebook, Twitter, Instagram, Wechat, etc. (Eveline A. Crone & Elly A. Konijn, 2018a). Social networks allow adolescents to share information, ideas, opinions, messages, images, and videos (Eveline A. Crone & Elly A. Konijn, 2018a). Adolescents extend their network beyond their family, biologically, emotionally, and developmentally (Patton et al., 2016b), even to those they never met face-to-face (Sklenarova et al., 2018). Engagement with social networks supports social and emotional development and functions as a platform to connect with the real world (Patton et al., 2016b).

Social networks play an important role in adolescents' life because they start to disconnect from the deep bond with family and engage in independent decision-making for the first time in their life (Thomas W Valente, 2010). Internet has become an integral part of everyday life (Sklenarova et al., 2018). Adolescents are massive internet users and use it for their leisure time activities more than adults (Susanne E. Baumgartner, Patti M. Valkenburg, & Jochen Peter, 2010). The impact of social networks on adolescents has increased enormously in the last decade with increased access to online social networks (Sklenarova et al., 2018) and social networks (Eveline A. Crone & Elly A. Konijn, 2018b). Over the past decades, researchers have agreed on the 'small world phenomenon'. Small-world networks refer to those networks that show dense interconnectivity and local clustering. These networks include bridges that connect between subgroups, and they can connect to people from distant clusters. People who occupy a central position can communicate more efficiently, though they have few connections (Thomas W Valente, 2010).

The online and offline social networks of adolescents are overlapping. In a decade ago, the studies of 2008 and 2019, it showed that online and offline social networks of adolescents were overlapped moderately, and the patterns suggested that adolescents use online contexts to strengthen offline relationships (Reich, Subrahmanyam, & Espinoza, 2012; Subrahmanyam, Reich, Waechter, & Espinoza, 2008). The study in 2019 emphasized that adolescents used online to expand and diversify their friendship network and empowered disadvantaged groups by enhancing weak ties in addition to strengthening the offline networks. It said that whether the friendship starts from online or offline was less important as soon as newly formed friendships move to communication modalities such as face-to-face contact or mobile phone conversation (OECD, 2019). Gradually, online social networks play role in the adolescents' sexual life. The recent survey of 219 adolescents in US aged 15-17 adolescent found that nearly 60%of adolescents who used online dating apps reported having met people from this apps in person, and nearly 90% of these reported at least one online-met sex partners (Macapagal, Kraus, Moskowitz, & Birnholtz, 2020).

Online and offline social networks complement each other. Facebook users were more likely to search for people with whom they have an offline connection to add as friends rather than complete strangers. Most US teens use social network sites to keep in touch with their offline friends (boyd & Ellison, 2007). Therefore, one should note that the on-line and offline networks of adolescents are connected; however, these two worlds are not identical. Friends listed at the top of online social networks might not be the same as those listed as the top face-to-face friends on offline networks. These online social networks provide both opportunities and limitations for adolescents; for example, they can create their public profile to extend their online networks, but at the same time face-to-face interactions disappear (Subrahmanyam et al., 2008).

Social networks and the general health of adolescents

Researchers have found that social support and social networks are means of influencing health outcomes. Studies showed relationships between social support and social coping and social support and general health and well-being. Social support consists of emotional, instrumental, informational, and appraisal support. Emotional support of friends and family consisted of conveying sympathy, concern, care and empathy to those who were in need. Instrumental support consisted of money, goods, aids, services, and equipment. Informational support consisted of advice, knowledge, suggestions, and tools that were helpful to those in need. While appraisal support provided feedback or analysis to someone to reflect his or her condition (Thomas W Valente, 2010).

Social network researcher Valente (Thomas W Valente, 2010) argued that there is no health topic that is free from a social network perspective. Studies explored health issues from a social network

perspective such as HIV/STD transmission through sexual contact networks, substance abuse including injection drug use, suicide, romantic relationships, physician behaviour, smoking, contraceptive use, obesity, etc. Social network analysis was also applied in the study of individual behaviours, interorganizational collaborations, and communication in the delivery of health services. The recent systematic review of social network analysis to study health behaviours in adolescents found that out of 201 studies, most of the social network analysis for adolescent health behaviours extend to tobacco and alcohol use, and studied the peer influence, and the effect of sociometric position on health behaviours. Most of the studies used sociocentric approach (90%), and 8% used egocentric approach (Collonnaz et al., 2022).

The importance of social networks has been growing in the public health and medical fields in the last decade, especially in the following areas: (1) the social influence on mortality and morbidity, (2) HIV/STDs and family planning, (3) community health projects applying social network analysis to improve message dissemination and program implementation, (4) inter organizational collaboration to improve the provision of health services, (Thomas W Valente, 2010). Researchers also approached the most recent COVID19 pandemic with a social network approach (W. Ahmed, Vidal-Alaball, Downing, & López Seguí, 2020), for example assess whether social networks were related to COVID19 conspiracy theory.

The network structure was shown to be crucial in community health interventions. Kelner and Wellman (1991) showed that information flows within a community are dependent on both individual and group network properties. If we understand the variables of a social network structure, public health programs could be created more efficiently (Thomas W Valente, 2010). Not only patients, but also health care providers rely on people in their network for decision making. One of the examples is physicians who were well integrated into the medical community showed early adaptation to a new drug by network discussions (Thomas W Valente, 2010). Peer-led sexual health education approach was found to have a good reach in adolescent health education program. Peer supporters were well connected and a good mix with other students, and 58% of the students reported exposure to the peer-led sexual health education program (K. R. Mitchell et al., 2021).

Social network analysis was recently applied to understand the transmission of infectious diseases such as sexually transmitted infections (STI), tuberculosis (TB), and malaria. It is useful to apply network analysis to learn the spread of these diseases because transmission occurs through person-to-person contact. In the early days of the HIV epidemic, Klovdahl (1985) tried to evaluate how the HIV outbreak and spread occurred through personal relationships within social networks (Klovdahl, 1985). Researchers continue to apply social network analysis in the health sector for various purposes. Health authorities used it for contact tracking to identify infected individuals and groups. These tools and methodologies are now widely used to draw network graphs to assist in the control of infectious disease transmissions (Thomas W Valente, 2010).

Adolescents tend to select like-minded people in their network. The proportion of smokers in networks explained by smoking-based friends' selection of friends was very prominent over time (Mercken et al., 2013). Social support was strongly associated with susceptibility to initiating smoking among non-smokers, as well as the willingness to stop smoking (Roberts, Nargiso, Gaitonde, Stanton, & Colby, 2015). Smoking-based friends selection in adolescent networks was significant in social network analyses of adolescents in six European countries (Mercken et al., 2009). Some studies researched about peers influences, and found proximity exposure predicted smoking, and smoking also predicted friendship formation with smokers (Khalil, Jones, & Fujimoto, 2021), and students who had social norms favourable towards smoking had more friends with similar views than the students with

perceived norms against smoking (Montes et al., 2023). Those who selected the new friends who vape was associated with becoming an vaper, and friend vaping was also associated with individual vaping (T. W. Valente, Piombo, Edwards, Waterman, & Banyard, 2023) .

Social influence and the homophily effect are prominent in adolescent obesity (Shoham et al., 2012), and life-style based similarities (C. T. Lee et al., 2022) Overweight adolescents were twice as likely to nominate overweight friends as their close friends rather than normal weight friends (Koehly & Loscalzo, 2009). A systematic review of social network analysis and physical activity in adolescents found that homophily, centrality and network composition were related to the physical activity of adolescents, and usefulness of social network analysis in the intervention of physical activity in adolescents (Prochnow, Delgado, Patterson, & Umstattd Meyer, 2020) . It was also found that social networks represent a tool to promote health interventions for the obese adolescents (Guevara-Valtier et al., 2021).

Friendship nominations between two students who shared a similar frequency of alcohol use frequency were 3.6 times more likely than between identical students with different frequencies of alcohol use frequencies (Wenzel, Hsu, Zhou, & Tucker, 2012). Adolescents selected friends based on similar unhealthy weight control behaviours. Adolescents had 7.4 times higher of forming friendships with an adolescent who shared his level of unhealthy weight control habits compared to those with different weight control behaviours. (Simone, Long, & Lockhart, 2018) Overweight youth who took meals together with overweight friends ate more than they did with non-overweight friends (Salvy et al., 2009).

Behaviours can be transferred among adolescents in the same network. Those who had smoker friends in their network in grade 6 predicted the potential of smoking in grade 6 and grade 7. The influence of smokers at grade 6 also predicted the selection of smoking friends at grade 7 (Hall & Valente, 2007). Having peers who drink heavily was significantly associated with heavy drinking in white homeless youth (Wenzel et al., 2012). Marijuana use was positively associated with reciprocal friendship bonds (Tucker et al., 2014). Adolescents with drinking friends had a higher risk of adopting the habit of drinking (Huang et al., 2014). Having problematic peers in the network such as behaviour of stealing, drug overdosing, being arrested, or being a gang member increased the likelihood of HIV risk-taking behaviour in homeless adolescents (E. Rice, Milburn, & Rotheram-Borus, 2007).

A higher prevalence of substance use-related behaviours among network members included having older peers in the network, having used illicit drugs with at least one network member, and the presence of conflict in the network (Tyler, 2008). An adolescent's risk of starting to use alcohol increased 34% for every additional friend who drank alcohol. (Mundt, 2011) Intense social interactions with smokers increased the probability of ego (the respondent) smoking probability (Miething, Rostila, Edling, & Rydgren, 2016). Another study revealed that having more physically active friends was significantly related to self-reported physical activity of respondents. (Voorhees et al., 2005)

Behaviours can also be transmitted between different networks of adolescents. In a study of migrant adolescents from six European cities, a higher proportion of social ties with non-migrants was associated with an increased use of cannabis (OR 1.07) and alcohol (OR 1.08). When popular migrants and popular non-migrants were compared, the former were less likely to engage in these risk behaviours (Lorant et al., 2016). Homeless youth who had more students in their networks were associated with a lower risk of heavy drinking (Wenzel et al., 2012) and homeless youth who had home-based friends in their networks were associated with a reduction in depressive symptoms (Eric Rice, Kurzban, & Ray, 2012).

Social networks and sexual health of adolescents

Adolescents use the Internet to satisfy their curiosity about sex (Mishna et al., 2018). Adolescent online and offline social networks influence their sexual behaviour in addition to their personal competencies and family factors (Gutierrez Fernandez et al., 2010). No matter where in the world, access to social networks brings online learning about sexuality and sexual behaviour (Sklenarova et al., 2018). More than half of the respondents from the three Asian cities reported having learned about sex from the Internet (45-84%) (Lou et al., 2012). In another study, 70 % of young people reported sending or showing someone sexual pictures of themselves, in which they were nearly nude, during the last year (Landry et al., 2013). Sklenarova H (2018) indicated that 51% of adolescents experienced online sexual activity mostly with peers (84%), but some with adults (Sklenarova et al., 2018). The increase of internet access can provide adolescents with new outlets to engage in risky sexual behaviour (Sanchez, Munoz-Fernandez, & Vega-Gea, 2017; Shilo & Mor, 2015; Vandenbosch et al., 2016).

Previous studies revealed that Internet-based sexual activities were associated with risky sexual behaviours and other risk behaviours. Those who shared sexual photos online were associated with concurrent sexual partners and substance abuse (Arulogun et al., 2016; Ybarra & Mitchell, 2014) and low self-esteem (Arulogun et al., 2016). Young MSM 'sexters' were more likely to be sexually active and to have anal sex with or without condoms than those who did not engage in sexting (Bauermeister et al., 2014). Adolescents who regularly engaged in sexting were more likely to have emotional problems and alcohol use than those who did not (Sevcikova, 2016), Those who had sexting practice were more likely to have had an sexual intercourse than those who did not have (relative risk 1.54, CI 1.14-2.08) (Bukenya et al., 2020a). Those who had higher degree of ponography addiction were more likely to have the risky sexual behaviours in adolescents (Yunengsih & Setiawan, 2021).

Adolescents exposed to porn films were more likely to have oral sex (48.3%) and to have multiple sexual partners (11.65%) (Arulogun et al., 2016). Having more than 100 SMS per day was associated with having ever had vaginal sex OR 2.01 (1.02- 3.99) (Landry et al., 2013). Meeting someone online and having sex offline were associated with an early sexual debut (10-14 years old) in Swedish youth (Jonsson et al., 2015). Those who had more access to chat rooms, dating websites and erotic contact websites were more likely to have a earlier initiation of romantic relationships (Vandenbosch et al., 2016); to experience cyber victimization (Wright et al., 2018) and to face cyber aggression (Mishna et al., 2018).

Those who have a connection with adolescents who engaged in risky sexual behaviours were associated with those risky sexual behaviours. In the study by Wang and Muessig, respondents who had a friend in their network who participated in commercial sex were 56 times more likely to follow suit (Wang & Muessig, 2017). In Africa, being a member of a close-knit camp in which concurrency was the norm was associated with practicing concurrency (Yamanis, Fisher, Moody, & Kajula, 2016). Social network members who met on the street were more likely to be perceived as having sexual risk (Wenzel et al., 2012). Affiliation with antisocial peers increased the odds of having a first sexual experience early in Ghanaian adolescents. (Bingenheimer, Asante, & Ahiadeke, 2015). Young black MSM who engaged in condomless sex showed that they formed a group of friends practicing the same behaviour (L. E. Young, Fujimoto, & Schneider, 2018b).

On the other hand, those adolescents who bonded with friends who engaged in healthy sexual behaviour were more likely to do so. In the US, a study found that a 10% increase in the proportion of classmates who used contraception increased the likelihood of individual contraception use by

approximately 5% (Ali et al., 2011). In networks where condom use was the norm, study respondents were more likely to use condom in commercial sex (Wang & Muessig, 2017). Unprotected sex was less likely to occur in dyads where participants had high safe sex attitude scores and in dyads where both members encouraged each other to use condoms (Gyarmathy & Neaigus, 2009). In another study, homeless adolescents, who had prosocial peers in their networks who attended school, had jobs and had positive family relationships, were less likely to engage in risky sexual behaviour (E. Rice et al., 2007). Homeless adolescents who had someone on their social network with whom they could talk about love and sex were associated with increased knowledge about HIV and less chance to participate in exchange of sex for materials (S. D. Young & Rice, 2011).

Social networks and age of first sexual exposure in adolescents

The age of first sexual exposure in adolescents is influenced by the social networks in which the adolescents are in. Social network attributes that are significantly associated with the age of first sexual exposure are people in adolescents' networks, norms of their peers, types of peers, the connection with their parents, and connectedness with school.(Kirby, 2002; Offiong, Lindberg, Jennings, Dittus, & Marcell, 2019) Having a higher quality of family interactions, connectedness, greater parental-child communication about sex, and birth control were associated with late initiation of sex. Those who showed greater connection to school and those who had better school attendance were more likely to have a late initiation of sex. (Kirby, 2002)

Having an older age peer group and close friends, having peers with poor grades and high nonnormative behaviour, peers with lower orientation toward achievement, peers who drink alcohol, peers with permissive attitudes towards premarital sex and sexually active peers were associated with early initiation of sex (Kirby, 2002). Offiong (2019) also explored factors associated with the early onset of sex in urban young men and found that having a partner of older age and weak parental relationships were associated with the early onset of sex (Offiong et al., 2019).

There is conflicting evidence on the social networks of adolescents and their age of first sexual experience. Landry et al. (2013) examined Latino adolescents' media use and sexual behaviours and found that having more than 100 SMS per day was associated with having ever had vaginal sex OR 2.01 (1.02-3.99). In contrast, a study from Ethiopia found that early sexual initiation was not correlated with social connectedness (Handebo et al., 2018), while a study from Korean adolescents discussed that internet use was not associated with a lower risk of sexual initiation (D. Y. Lee et al., 2012). Social network use and its association with the early onset of sexual experience is still needs tobe explored more to gain a wide understanding.

2.3. Social network analysis for adolescents' sexual behaviours

Social network

'A social network is a set of relations that encompass a set of social entities and additional information about these actors and the link between them" (Borgatti, 2020). A network is defined as a set of nodes connected by links from one to another. These nodes could be persons, groups or other units, and the links could be asymmetrical or symmetrical (Borgatti et al., 2013; Prell, 2011).

Social network analysis (SNA) is a unique approach to understanding the social world. SNA consists of a conceptual, methodological, and analytical toolkit. SNA developed from multiple interactions among academics from multiple disciplines. Harvard's sociology department started to develop SNA concepts and analytical techniques (Prell, 2011). Social network analysis is a way of thinking about social systems to learn the relationships among those who are composed of that system, i.e. actors, nodes, or vertices. The position of someone in the network, the distance between network members, the spread of the network, and the density of the network are calculated using mathematical formulas embedded in the SNA software (Borgatti et al., 2013; Prell, 2011). Nodes consist of individual persons or a group such as teams, firms, cities, countries, or whole species. A tie is a link between nodes creating a path across nodes to form the connected network (Borgatti et al., 2013).

There are two main social network approaches: the whole social network (sociocentric network) and the personal network (egocentric network) (Prell, 2011). In the sociocentric network, the entire network is taken into account (Borgatti et al., 2013; Prell, 2011). A sociocentric network could involve many personal networks because it is a collection of networks of many individuals (Klovdahl, 1985).

In the egocentric network approach, we focus on the personal network of a respondent, who is also referred to as the 'ego' of that social network. Those who connected to the respondent, 'ego', in the network are called 'alters'. Tie is the connection that links between either the ego-alter or the alter-alter. Every alter connects to an ego because an egocentric network is focused on an 'ego'. However, the link between alter to alter may or may not be present. The links between alters are also independent of the ego. Ties have attributes, e.g., frequency, level of closeness, reciprocity, and direction, etc. Nodes also have specific attributes such as age and gender (Borgatti et al., 2013; Prell, 2011).

Social network analysis is categorised into three levels; the dyad level, the node level and the network level. At the dyad level of analysis, the pairwise relation between actors is analysed. For example, the research question would be: "Do pairs of actors with business ties tend to develop effective ties?". At the node level, most of the analysis is the collection of node level measurement, like how many ties an actor has. At this level, the research question could be: 'Do actors with more friends tend to have a stronger immune system?' At the network level, the whole network is analysed as a single number. At this level, the question would be 'Do well-connected networks tend to diffuse ideas faster?' (Borgatti et al., 2013).

Social network analysis provides us with an in-depth understanding of the behaviours which are distributed in a network and factors associated with these behaviours. Network information is useful to assist in formulating the policy agenda to promote behaviour change or create interventions to reduce the negative consequences of spreading unhealthy behaviour. For example, network analysis can predict leaders in networks to be targeted for health behaviour interventions (Borgatti et al., 2013). Networks can be applied to find those who bridge the gap in the spread of unhealthy behaviour and diseases (Rosen et al., 2020; Thomas W Valente, 2010).

In the HIV research area, some researchers have applied social network analysis approaches to trace transmission networks. Although their approaches to SNA were diverse and some studies did not apply the proper SNA methodology, the findings were valuable for the approach to HIV control. Klovdahl (1985) proved that HIV was transmitted by sexual networks using sexual contact data collected by the Centers for Disease Control and Prevention (CDC). There were some more studies that demonstrated social networks and spread of HIV/STI infection (J. D. Fisher, Fisher, Misovich, Kimble, & Malloy, 1996; Schneider et al., 2013; Townsend, Zembe, & Mathews, 2013).

Some scholars also developed mathematical models and computer simulations for a better understanding of HIV spread by the social network approach (Thomas W Valente, 2010). A social network researcher, Morris found some interesting associations between social network attributes and the HIV epidemic; the mean number of partners per individual in the population had an influence on the speed of the HIV epidemic (Kretzschmar & Morris, 1996); concurrent partnerships increased the speed of HIV spread as having multiple sexual partners (Martina Morris, 1995; Morris & Kretzschmar, 1997); and the bridge population was as important as the core risk group for the spread of HIV infection (Morris, Podhisita, Wawer, & Handcock, 1996).

Few recent studies have applied a proper SNA approach in adolescent health research (Christopher R. Browning, Brian Soller, & Aubrey L. Jackson, 2015; E. Fearon et al., 2019). Browning (2015) studied the reinforcement of network density and sexual activity in the last six months prior to their study (C. R. Browning et al., 2015b). Fearon (2019) explored friendship density (network density) and ever having sex E. Fearon et al. (2019).

The current study focused on ego network analysis, the network in which each node is an individual, and the links are personal relationships between individuals of the network. The study explored the social network of adolescents at three levels: network level, dyad level and node level. Ego density was determined at the network level; the average tie strength at the dyad level, and degree centrality, betweenness centrality, efficiency, and constraint at the node level.

Ego network and ego density

One's behaviour can be shaped by the structure of the network, a close network in which the friends know each other, compared to a loose network in which one's friends do not know each other. The network structure can also be set to attain a certain goal such as to reduce the risk of the people in the network (Granovetter, 1973).

In the ego network, the analysis focuses on an ego which is alternatively called an individual actor or a node. The network consisted of 1) ego and 2) alters, that is, nodes that connected to ego, and 3) ties that connected between ego and alter or alter and alter. In the analysis of the ego network, measurement involves: (1) the size of the ego network, i.e. how many alters an ego has; (2) the density of the ego network, i.e. the extent alters connect to each other and; (3) the tie strength, i.e., the strength of the ties between ego and alters (Borgatti et al., 2013; Prell, 2011).

Ego density is defined as the percentage of all possible ties in the ego network that are actually connected to each other, excluding the ego (Prell, 2011). Epstein (1969) suggested that different parts of an ego network may have various levels of density. In his definition, 'the network in which people interact most intensely and are most regularly and likely to get to know each other' is an effective network and the remaining networks are 'extended networks'. A density of 1.0 implies that every alter is connected to every other alter, and 0 means none of the alters know each other (McCarty, 2002). For example, the density of the Jim ego network is denser than that of Sophia (Figure 2.6).

A high-ego density network is either good or bad for health behaviours according to the context of the behaviours. The norms and the sense of belonging were strong in dense networks. In dense personal networks with traditional gender roles, people were more likely to divide household work and more fond of socialization (Prell, 2011). Similarly, in the study of intravenous drug users, dense and complex personal networks were more likely to share needles than less dense networks (Latkin, Glass, & Duncan, 1998). Close intravenous drug users' networks rarely admit new members. This kind of small network has been associated with a low network turnover and a lower opportunity for external

pathogens to engage in the network (Wylie, Shah, & Jolly, 2006). However, this type of dense network was associated with faster spread if one of those network members got infected (Verdery, Siripong, & Pence, 2017).

In HIV studies, dense networks were associated with beneficial results among respondents. Young black MSMs from a high-density network reported higher rates of HIV status disclosures to their network members compared to those from networks with high turnover (McFadden, Bouris, Voisin, Glick, & Schneider, 2014). Regular HIV testing was more common in those who belonged to close and secret groups (L. E. Young et al., 2018b). A close friendship network of people living with HIV AIDS (PLWHA) or caregivers was associated with less anticipated stigma (Wu, He, Guida, Xu, & Liu, 2015). Browning (2015) tested the implementation of the network (similar to the concept of ego density) with having sex in adolescents and found a negative association between these exposures and outcome C. R. Browning et al. (2015b). In contrast, Fearon (2019) found that a lower friendship density was not associated with having sex (OR 0.96, 95% CI 0.93-1, p=0.05) E. Fearon et al. (2019).

Ties strength and direction

Granovetter (1973) defines the strength of a tie as a combination of time, emotional intensity, intimacy (mutual confiding), and reciprocal services. These attributes characterize the relationship between network members. The strength of the tie increases as frequency, emotional intensity and mutual confiding between individuals grow. A person could have many ties in his or her network, some ties could be more intimate, frequently contacted, and have mutual understanding than others (Prell, 2011).

Both strong and weak ties are significant in their own way. Weak ties are connecting different groups for quick transmission of information. Strong ties are important in behaviour change because people tend to be influenced by close members rather than distant ones (Thomas W Valente, 2010). The strength of the tie is not always stable among the network members. In a Baltimore drug user study, respondents were asked to mention five close friends at the beginning of the project and six months after that. The results showed that only 29% of the close friend's name at baseline was similar with that of the follow-up survey (Thomas W Valente, 2010). It indicates that a close friend can become a distant friend at any time whilst the opposite could happen.

The effect of strong ties could be positive or negative depending on the type of network. Valente (2001) conducted a study to evaluate the influence of strong ties in social interaction. In this study, respondents were asked to provide the initials or nicknames of five close friends. The assumption was that those nominated first were the closest friends with the strongest ties, those listed second, would be the next closest, etc. The researcher followed needle-sharing behaviours between each of the participants and their five friends for some months. He found that needle sharing was more likely to occur between the respondent and the friend listed first or second rather than those listed third, fourth, and fifth. It shows that close friends or strong ties were associated with the replication of behaviours among these network members (Thomas W Valente, 2010).

There are studies that show that strong ties bring benefits to adolescents. The enforcement of the network (two-mode networks that linked residents through socio-spatial overlap in routine activities) was found to be negatively associated with substance use and sexual activity scales (C. R. Browning et al., 2015b). Bellair (2010) revealed that cohesive informal neighbour networks, composed of frequent interacting individuals, maintain strong connections between one another in the network. This kind of network was an effective means of keeping control over crimes among adolescents (Bellair & Browning, 2010; C. Browning, Feinberg, & Dietz, 2004). Interaction with neighbors would prevent

adolescents from adverse behaviour because networks improved informal control, and informal control reduced crimes (Bellair & Browning, 2010).

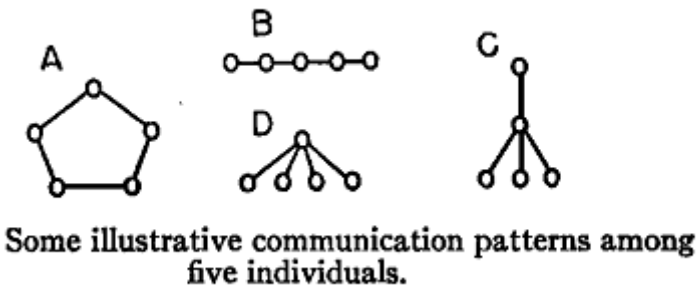
The role of weak ties was explored by Granovetter (1973) in his doctoral thesis. He investigated among people who recently were offered a job, how they received information about a job vacancy. Only 15% of the respondents received this information from regular contacts, whereas 55% picked up this information from the people they contacted occasionally, and the remaining 29% obtained this information from those they rarely contacted. Granovetter concluded that weak ties, in terms of frequency of contact, were a more important source than stronger ties in finding a job. Weak ties were found to be useful in networks in disseminating new information between different subgroups in networks (Ronald S. Burt, 1992; Granovetter, 1973).

The weak ties are useful in unique ways. Weak ties create bridges to connect different segments of a network to diffuse information beyond the boundaries of dense subgroups (Thomas W Valente, 2010). Granovetter (1973) recognized that weak ties are effective in linking information between different groups, especially if these groups were dense, circulated redundant information, and had structural holes (Ronald S Burt, 2004). A structural hole is a gap between two individuals who have complementary sources of information. Burt (1992) suggested that a person who was able to fill structural holes can occupy a critical position in the network (Thomas W Valente, 2010).

Centrality

The idea of centrality in human communication was introduced by Bevalas in 1948. He hypothesized that there is a relation between structural centrality and influence in a group processes. He did two research and concluded that centrality was related to group efficiency in problem solving, leadership perception, and the personal satisfaction of participants (Bavelas, 1950; Freeman, 1978).

Bavelas (1950), explained an experiment conducted by Leavitt (1940). Leavitt ran an experiment to test the hypothesis that a recognized leader is the one who occupies the highest centrality position. For that experiment (see figure), he set persons in different network patterns i.e. A, B, C, and D and let them perform the same task. After a period of time in the experiment, he asked the questions to the subjects 'How much did you like your job?' and 'How satisfied are you with the job done?' Men in the peripheral positions provided low scores, while men in the central position provided high scores for liking one's job and satisfaction with the job done (Bavelas, 1950).



Some illustrative communication patterns among five individuals.

Figure 2-1 Communication pattern in task-oriented groups (Bavelas, 1950)

He found that in pattern D, peripheral men sent information to the man in the centre where information only arrived and was sent out. Pattern C was a bit similar to pattern D, but a bit slower due to the evolution of a middle person. In pattern B, the most central person or two from either side of the central person participated in information exchange. Therefore, the pattern was not as stable as C and D. Pattern A rarely sent information to someone on the network because they all received and worked out the answer themselves. He concluded that the most centralized person, for the purpose of information, was most satisfied in the job (Bavelas, 1950).

After Bavelas' theory, Freeman (1979) and Borgatti (2006) also strengthened the concept of centrality. They suggested that centrality is the extent to which a person has an important position in the network. The number of choices a person receives from others in the network can predict the centrality of that person. Central persons are also those that newcomers approach when they join a network. Therefore, a central person can provide a bridge between the various parts of the network to become a small world network (Thomas W Valente, 2010). Freeman (1978) found that the highest centrality index lies in the star-shaped or wheel-shaped network (Figure 2.9). The lowest centrality index lies in the complete graph, where all possible edges are present because all points in the graph are homogeneous in nature (Freeman, 1978; Prell, 2011).

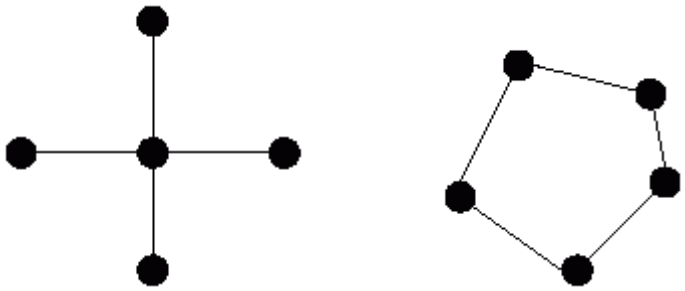


Figure 2-2 Star-shaped network vs. wheel-shaped network (Prell, 2011)

The central person benefits from that position due to various factors. The central person has the advantage of viewing what other people on the network do (Freeman, 1978). The central person has access to information and can control information on the network and is also able to reach out for support and material aid easier than other members (Borgatti et al., 2013). The central person could be involved in the evolution of behaviour in the network as an opinion leader who has tremendous influence in the spread of information (Thomas W Valente, 2010). Centrality is also related to the efficiency in group problem solving, since it is associated with control, independence, and activities (Ronald S. Burt, 1992; Freeman, 1978).

The advantage or disadvantage of a central person depends on the context of the networks and the things that are flowing in the networks, such as good behaviour vs. bad behaviour. Some studies predicted positive outcomes for the central person in the network, such as wealth and status, health, and life satisfaction (Borgatti et al., 2013). Pitts (1965) examined the importance of centrality in communication paths for urban development. He restructured the nineteenth century network of river transportation in central Russia to understand the popularity of the modern city Moscow and how it emerged among other cities in that area. He found that Moscow occupied the center of the medieval Russian transportation and communication network (Freeman, 1978). However, in the context of infectious disease epidemiology, the person in the central position within a network engaging in face-

to-face interaction with network members is at increased risk of contracting contagious diseases (Borgatti et al., 2013). In this study, we will focus on degree centrality and betweenness centrality.

Degree centrality

Degree centrality is a measure that aggregates the ties directly received or given by an actor in the network (Prell, 2011). Freeman (1978) defined it as a number of connections or ties someone has in his/her personal network (Hemmati & Chung, 2016). It is simply measured by the number of choices one receives from others or sends to others in the network (Thomas W Valente, 2010). It is the standard representative of centrality because it is straightforward to interpret (Landherr et al., 2010).

Prell (2011) suggested that degree centrality is simply the count of the number of alters adjacent to ego regardless of the direction or value of the tie. It is to investigate whether that person is a major channel of information in the network. The more ties an actor has, the quicker information he/she could spread into the network. The higher the degree of centrality, the greater the chance that the actor interacts with others on the network (Prell, 2011). A person with high degree centrality could have emotional support or has more opportunity to engage in social events. In an organizational setting, nodes with high degree centrality determine the importance of a person in the group. In the context of disease transmission, it would be an index of exposure to a certain disease in the network (Borgatti et al., 2013).

Popularity, having a high degree of centrality, is a crucial issue in adolescents' health that we should focus on, because it is related to peer acceptance, which is important among adolescents. The notion of popularity in adolescent groups, called leading the crowd, existed before online social networks appeared. The study of adolescents' society conducted in 1958 in the United States revealed that those who were mostly nominated by friends were called 'leading the crowd' in schools receiving the attention of other students. They had prominent variables that made them stand out from the rest of the students. It could lead to either positive or negative behaviours depending on the major social class of students in schools (Coleman, 1961).

Popular students are also opinion leaders in schools. These opinion leaders usually adopt new ideas earlier than others on the network. They try to reinforce their acceptability in the group by introducing new behaviours that their followers might like. They are also good communicators who enjoy interpersonal interaction, are more active in social media, and are happy to retrieve information from online sources that makes them trendsetters among other members in the network (Thomas W Valente, 2010). The influence of a friend in adolescents was found to be stronger if that friend was popular in the school network (Tucker et al., 2014).

From a behaviour intervention perspective, popular adolescents are good entry points into their social networks for behaviour change communications (Thomas W Valente, 2010). At the early introduction of contraception, Roger and Kincaid (1981) investigated which was the most widespread contraception method among IUD, condoms, or withdrawal in a village. They found that the method used by young women who were popular and trusted in the village (i.e., who received the most nominations as a family planning discussion partner)) was the most popular method among young women in that village (Thomas W Valente, 2010).

Popularity was associated with appearance in adolescents. There was a significant correlation between popularity and better dental brushing habits in female adolescents (Sadeghipour, Khoshnevisan, Jafari, & Shariatpanahi, 2017). Physical appearance also influenced the nature of friendship among adolescents. Overweight adolescents nominated more friends; however, friends did not nominate

them as equal as they did for friends with normal weights (Koehly & Loscalzo, 2009). Obese adolescents were less socially integrated than non-obese ones and had fewer friends (Ali, Amialchuk, & Rizzo, 2012). Friendship ties between obese youth and non-obese youth were one direction from obese to non-obese rather than reverse (Schaefer & Simpkins, 2014). Christakis also learned that weight gain in one person was associated with weight gain in his or her friends, siblings, and spouses, and she suggested that network phenomena was relevant to the biologic and behavioural trait of obesity, and obesity disseminated through social ties (Christakis & Fowler, 2007).

Having more friends was associated with the probability of acquiring new sexual partners in Ghanaian adolescents (Bingenheimer et al., 2015). Valente (2010) explained the possible reason why popular students are more likely to smoke than other students. His reason was that popular adolescents wanted to retain their popularity; therefore, they tried to remain trendsetters. It might also depend on the norms to the network of which the students belong. If the norm is disapproval of smoking on the network, the popular adolescent might adapt that behaviour to maintain their popularity (Thomas W Valente, 2010).

In some studies, popularity was found to be associated with risk factors such as smoking, alcohol use, and having multiple sex partners. Alexander (2001) showed that popular students were more likely to smoke than nonpopular ones. Valente (2005) also supported that finding according to his research about smoking and popularity in students (Thomas W Valente, 2010). Popularity in a social network was associated with smoking and becoming a smoker in various studies (AOR 1.67) (T. W. Valente, Fujimoto, Soto, Ritt-Olson, & Unger, 2013). Popular students with many nominations were found to be at high risk for tobacco use (Ramirez-Ortiz, Caballero-Hoyos, Ramirez-Lopez, & Valente, 2012). Others illustrated that alcohol consumption leads to increased popularity in adolescents (Alimenti, 2014). Hahm, Kolaczyk, Jang, Swenson, and Bhindarwala (2012) indicated that the most prestigious adolescents had the highest risk of binge drinking. The onset of an adolescent's risk of alcohol use increased 13% for every additional popular friend (Mundt, 2011).

Betweenness centrality

Freeman (1978) defines betweenness centrality as a measure of how often an ego (a person) falls along the shortest path between two alter nodes (people in the networks) (Freeman, 1978). Betweenness centrality predicts potential control over information flow (Borgatti et al., 2013).

Betweenness centrality is the best indicator among the attributes of the social network because it provides a high variance between the members of the network compared to other attributes of the social network (Prell, 2011). It provides a strong demarcation between the scores of central actors and non-central actors (Borgatti et al., 2013). A score of hundred for centralization of the entire network explains that person serves as a bridge for all other people in the network, e.g. a central person from the star-shaped network presented below. Zero-betweenness centrality implies that person does not serve in a broker position in the network (McCarty, 2002).

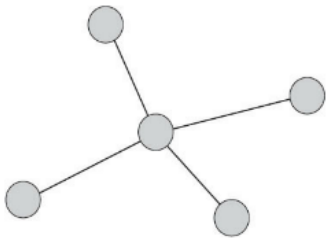


Figure 2-3 A star network with five nodes (Borgatti et al., 2013)

A recent study on drivers of the social network and COVID-19 conspiracy theory found that those who had the highest centrality of betweenness in the network to share information could be ordinary citizens among celebrities, activists, and influential social network users who had much more followers (W. Ahmed et al., 2020). It showed that anyone in the network could have high betweenness centrality regardless of his or her influencing power in the network.

Betweenness centrality serves different purposes. It serves as the broker position of one in networks. It also provides a gatekeeper role to control communication flows in the network (Borgatti et al., 2013). The high centrality of the betweenness represents the most important actors in a network, in another way, the influential leader in social networks (Prell, 2011). In organizational management, those with high centrality could transfer innovation from one network to another as early adopters (Thomas W Valente, 2010). The downside is that these persons can also filter information, manipulate, or distort information; therefore, persons with high betweenness centrality could pose a threat for networks in the business world (Borgatti et al., 2013). In the business sector, those who had a high-betweenness centrality position were those who had more opportunity to access innovative technologies(Gilsing, Nooteboom, Vanhaverbeke, Duysters, & van Den Oord, 2008).

The centrality of the betweenness is an important concept in the context of health. Some studies applied a similar approach to the centrality of betweenness, such as the concept of a bridging group. A study conducted by Klovdahl (1985), at the early phase of the HIV epidemic, emphasized how some people serve as a bridging group between high-risk groups of being infected with HIV and the general population. The first index HIV patient in the US according to the Center for Disease Control and Prevention (CDC) was a homosexual flight attendant from the US. Similarly in the UK, two of the early British HIV patients were male homosexual airline stewards. It showed that a person can serve as a bridge to spread disease from one region, nation, or even continent to another (Klovdahl, 1985).

A study conducted in Africa found that elites who circulated between different urban areas and their own rural tribe areas spread infectious agents between urban and rural areas (Jacobson, 1970). Prostitution builds bridges between different groups and spreads infectious agents between different groups through sexual contacts. Soldiers, students and long-distance truck drivers who usually live individually far away from family can also provide these kinds of bridges via sex workers and general populations (Klovdahl, 1985; Little, 1960). If such bridges are not contained, diseases can be transmitted to different social networks through sex workers (Thomas W Valente, 2010). From a positive point of view, people in a between position could be important agents for health interventions. If an infectious agent can be blocked at his/her position, for example through vaccination, the pathways can be blocked (Klovdahl, 1985; Little, 1960).

Betweenness centrality was not much studied in adolescent health. A study by Bettinger (2004) investigated the bridge position in social networks in terms of perception of sexual risk and condom use among adolescents. In this study, adolescents were classified as core, bridge or periphery according to their own and their main sex partner's behaviour. If both partners exhibited one of the following risk behaviours: injection drug use, illicit drug use, concurrent sex partners, and/or binge drinking, they were classified as the core group. If the respondent or partner engaged in one of these behaviours, they were classified as the bridging group. Those who did not meet either of these two criteria were classified as the periphery group. Their prevalence of sexually transmitted diseases (STI) was followed for six months. The prevalence of STI was found to be highest in the core group, followed by the bridge group and finally by the periphery group. Furthermore, the researcher discovered that adolescents from the core and bridge groups perceived themselves as less at risk and rarely used condoms than those in the periphery group (Bettinger, Adler, Curriero, & Ellen, 2004). From these findings, it can be postulated that the betweenness centrality position, and the perception of risk by adolescents, and actual risk-taking behaviour are areas that need further exploration.

Structural hole theory

Burt (1992) developed the structural hole theory. In this theory, Burt focused on the information flow in the network. He assumed that non-redundant contacts in the network in terms of information were connected by a structural hole. A structural hole is a relationship without redundancy between two contacts. That hole acts as a buffer for sharing information between different groups. As a result of the hole between them, two contacts could provide network benefits that were additional rather than overlapping information (Ronald S. Burt, 1992).

Burt (2004) explained his structural hole theory in a simple way. Opinions, behaviours, and information are homogeneous within a group rather than between groups. Since people focus on activities inside their own group, it creates "holes", a simple word, in the information flow between groups. These are called structural holes (Ronald S Burt, 2004). The brokerage person can communicate between groups to exchange or access information, interpretations, and produce new ideas (Ronald S Burt, 2004). People with efficiency in the network can take this opportunity to fill these structural holes. The efficiency concept will be explained in the next section.

In the figure of the ego network presented below, Jim has a betweenness centrality score of 0.67 while Sophia's score is 6. It shows that Sophia has a higher betweenness centrality score because her ego network has more structural holes than Jim (Prell, 2011).

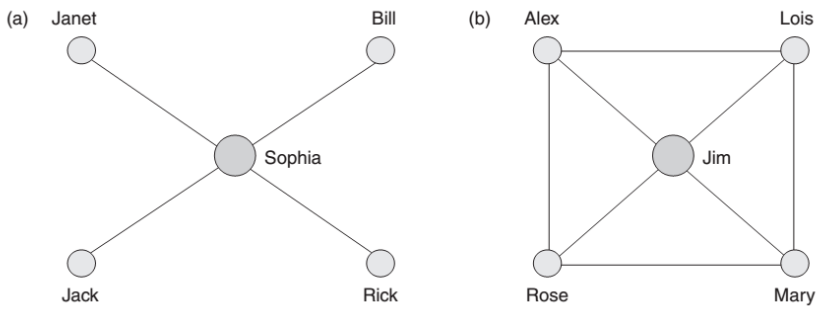


Figure 2-4 Advice on the work group (Prell, 2011)

The idea of centrality of the betweenness is exchangeable to that of structural holes. (Prell, 2011). In the previous chapter, we explained the weak ties. Granovetter (1973) highlighted that weak ties play a role in information access and flow between different groups. If there are structural holes between groups, information access and control can be created by spanning these holes by those who owned a high betweenness position (Ronald S Burt, 2004; Granovetter, 1973). In organizational management, those who can fill structural holes proportionately achieve good ideas, compensation, positive performance evaluations, and promotions. Brokers between groups are more likely to express good and valuable ideas and less likely to face dismissed ideas (Thomas W Valente, 2010).

Efficiency

In social networks, efficiency is related to the number of non-redundant contacts. The more non-redundant contacts a person has, the higher his/her efficiency will be for mobilizing opportunities and contacts (Hemmati & Chung, 2016). From an information perspective, redundant contacts in a network could provide the same information repeatedly. The term 'effectiveness' here refers to the average number of people reached per each primary contact, and the term 'efficiency' means the total number of people reached by all primary contacts. Therefore, effectiveness is the gain per primary contact, while efficiency is about the gain per entire network (Chung, 2009b).

The network expansion is illustrated in the figure below. In these three networks, network-A is the sparsest while network-C is the densest. The sparse network-A provides four non-redundant contacts. The dense network B contains four groups made up of eight persons; however, only one non-redundant contact for each cluster. Therefore, the total result of non-redundant information is four. In the densest network C, there are four clusters formed by 16 people but only one non-redundant contact for each cluster, and so the total result of non-redundant information is four again.

From an information efficiency perspective, the sparse network provides more benefits because it can send information to four separate areas of the social network efficiently. The denser network provides the same information in the network, since people in the network are strongly connected to each other. The denser networks-B and -C are not as efficient as the sparse network-A because the net information yield is similar among networks-A, B, and C, though networks-B and C have to invest more time and effort across more people in the network (Ronald S. Burt, 1992; Chung, 2009a).

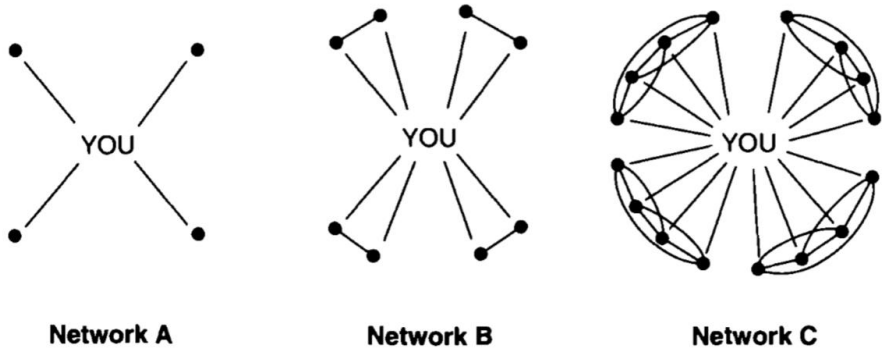


Figure 2-5 Network expansion (Ronald S. Burt, 1992; Chung, 2009a)

Non-redundant contacts like the four people in network-A are disconnected from each other. In the dense networks B and C, the members of each cluster have contacts in their own cluster. Such a dense network could happen between close friends, family members, people who have known each other for a long time, people who work together, and people who frequently gather on social occasions. They may share redundant information in their own cluster, and thus there is no structural hole for the third party (Ronald S. Burt, 1992; Chung, 2009a).

The structural hole theory contributed to the formulation of the efficiency concept. Efficiency is the ability to maximize the number of non-redundant contacts in a network to maximize the yield of structural holes per contact. If two networks are equal in size, the one with more non-redundant contacts gets more benefits in terms of the information because that one can spend time and emergency more efficiently (Figure). Therefore, maximizing the number of non-redundancy contacts in the network is a sort of maximizing the structural holes obtained per contact.

In the business world, efficiency and success are presented in a linear relationship. Sutton and Hargadon (1996) found that organizations with collaborative networks that can bridge structural holes in their markets were faster to learn, more creative, and more productive (Ronald S Burt, 2004; Sutton & Hargadon, 1996). Hargadon and Sutton (1997) also found that a brokerage position brought brainstorming functions in the business firm to create better product designs (Ronald S Burt, 2004; Hargadon & Sutton, 1997). The company achieved higher performance when managers could span relationships beyond the boundaries of their own industry (Ronald S Burt, 2004; Geletkanycz & Hambrick, 1997). Canadian companies in biotechnology grew revenues by linking multiple kinds of alliance partners (Baum, Calabrese, & Silverman, 2000; Ronald S Burt, 2004). Biotechnology firms that reached out to their diverse partners earned more than those who did not (Ronald S Burt, 2004; Owen-Smith & Powell, 2003). There has been no study of efficiency in the health of adolescents. The current study focuses on the network efficiency of adolescents.

Constraint

The constraint of social networks measures the drawback in opportunities by expressing the extent to which an ego (a person in the network) has invested time and energy with alters (other people in the network) to get a single contact (Burt, 1992). It measures the extent of the connections of an ego's connections to others, which are then connected to each other. Constraint is also a measure of the degree to which contacts of an individual are linked to each other and therefore describes the redundancy of contacts (Burt, 1992). In dense personal networks, the respondent's friends know each

other, and the constraint is high. In the sparse personal networks, friends of the respondent are less likely to know each other; therefore, the constraint is low. (Thomas W Valente, 2010).

Constraint is a reverse concept of efficiency in the network concept. Therefore, if a person has many connections to others who in turn have many connections to others, this person is quite constrained. In organizational management, constraint poses a barrier in producing new ideas in redundant networks because similar information would be repeated in densely connected groups (Hemmati & Chung, 2016). Research has shown that a high efficiency and low-constraint network is a place for a person to maximize the ability to produce good ideas, good performance, and enjoy one's career (Chung, 2009b). However, the bright side of constraint is that dense personal networks with high constraint provide reinforcement for existing norms and practices; therefore, it protects from outside sources of influence or risks (Thomas W Valente, 2010).

Theoretically, the concepts of constraint and network density are similar. The only difference is that the constraint focuses on the information available in a network. In a network with low constraints, there are many structural holes. Therefore, people in a low-constrained network can access these structural holes. In the business industry, those from a low-constrained network who can span structural holes gain professional success (Thomas W Valente, 2010). Dense personal networks with high constraints tie a person to reinforce the prevailing norms and practices. Therefore, network members are hard to influence by outsiders and are more protected from outside risks. In less dense networks, it could be easier for network members to access outside information. Again, that would be advantageous or disadvantageous depending on the behaviour we learned (Thomas W Valente, 2010).

Constraints and structural holes are negatively associated. If the network is highly dense and highly constrained, there is less chance to have structural holes with third parties. Constraint is also a way to measure the extent to which ego's alters (network members of the respondent) have ties to alters (network members). The higher the constraint in the network, the fewer structural holes in the network and the more time and energy someone needs to invade into the network (R. Burt, xa, & S, 2004). Logically, the social capital of a person can increase with increasing the number of alters in the network, but it decreases with increasing extent that alters are connected to each other (Borgatti et al., 2013).

In knowledge-intensive work, high efficiency and low constraints are useful indicators of an individual's ability to obtain useful knowledge from diverse and nonredundant contacts and therefore gain performance (Hemmati & Chung, 2016). In the business industry, the performance and value of manager ideas is negatively associated with network constraint (Ronald S Burt, 2004). The constraint of a manager is high if the discussion partners have connected and shared information with each other. More constrained networks have fewer structure holes for the manager to launch new ideas (R. Burt et al., 2004). In the context of organizations, people with high constraints are unable to produce novel ideas because they are overwhelmed with redundant information from densely connected clusters of people in their network (Hemmati & Chung, 2016).

Working definitions of social network variables in our study

The Working definitions of the variables of social network for our study were developed based on the theories and definitions from the literature review as follows. The mathematical calculation of these variables will be explained in Chapter 5. Methodology.

Ego density

We defined the ego density as a percentage of all possible ties in a person's network that are present.

Higher ego density means a network in which people interact more intensely, more regularly, and more likely to know each other. In simple terms, a network with a higher ego density it is a network in which people knew each other and interacted more frequently.

Average tie strength

We defined the average tie strength as a combination of time spent and emotional intensity between two people. In simple terms, it is a combination of time, emotional intensity and intimacy between network members.

Degree centrality

We defined the degree centrality as a measure that aggregates the ties directly received or given by a person in his/her networks. In simple terms, it is a sum of number of connections or ties or friends in his/her personal network.

Betweenness centrality

We defined the betweenness centrality as a frequency with which a person is on the shortest path between two other people in a network. In simple terms, a person who had higher betweenness centrality is a person being in a broker position.

Efficiency

We defined efficiency as a total number of nonredundant people reached by the primary contact. In simple terms, a person who had higher efficiency was a person who was able to reach more people in networks through their primary contacts.

Constraint

We defined the constraint as an extent to which a person invested time and energy to get a single contact in networks. In simple terms, network with high constraint was a network which a person needed more time and energy invested in obtaining additional contacts.

2.4. Influence of people in the network on the sexual behaviours of adolescents

Influence of peers on adolescents' sexual behaviours

Adolescents value their peers and family differently. Peer behaviour is one of the strongest influences on adolescents' behaviours (Clark et al., 2021). Peers mean a lot to adolescents (Patton et al., 2016b). Adolescents consider that peer acceptance and support are desirable social consequences and therefore desire to be in line with their peers. Various researchers revealed that adolescents engage in specific behaviours that are approved by their friends (Thomas W Valente, 2010). Sexuality among adolescents is also closely related to peer interaction (Sevcikova, Vazsonyi, Sirucek, & Konecny, 2013). The effects in terms of changes in attitudes, values, and behaviours due to health promotion and prevention are more effective in adolescent age groups than other groups (Patton et al., 2016b). The influences of peers have an impact on sexual behaviours as adolescents' personal competencies (Gutierrez Fernandez et al., 2010).

Adolescents need peer approval. Valente (2010) found that peer pressure was the hardest part for adolescents to overcome undesirable behaviours and adopt new behaviours. Adolescents rely on the health information provided by their peers of similar backgrounds but slightly higher in socioeconomic status than themselves. In the era of IT, peers connect beyond physical boundaries (Thomas W Valente, 2010). Rice (2010) found in homeless adolescents that having home-based peers in the network was associated with a 90% reduction in risky sexual behaviours such as having multiple partners and having sex without condoms (E. Rice, 2010). In homeless youth, those who talked more frequently about love and safe sex in their social networks were associated with greater knowledge of HIV knowledge (S. D. Young & Rice, 2011).

The relationship between peers and adolescents' behaviours could be in either direction whether the adolescents copied the behaviours from their peers or adolescents looked for peers with similar behaviours as themselves vice versa. Adolescents can adopt a new behaviour due to the influence of their friends. On the reverse side, adolescents can initiate a new friendship for a specific behaviour to which they are attracted. For example, if an adolescent assumes that smoking is cool, he or she may want to build a friendship with peers who smoke (Thomas W Valente, 2010).

Peer interactions result in health behaviours of adolescents depending on their sex and the kind of peers they are connected to. For example, peer acceptance and initiation of sex were inversely associated in females and directly in males (Kreager & Staff, 2009). Peer contact frequency was shown to be a protective factor for the age of onset of sexual activity and the use of contraception during the first and recent sexual activity in adolescents from Macedonia (Mladenovik, Spasovski, Kosevska, & Zafirova, 2010). Best-friend interactions increased the likelihood of early sexual activity among adolescents and the use of contraception during intercourse (Majumdar, 2006).

Reiner (2017) found that adolescents with higher peer attachment were less likely to have problematic internet use, such as internet addiction, in both men and females. In that study, peer attachment was assessed using a peer attachment score that consisted of 25 items. It can be assumed that peer attachment could reduce loneliness, improve social competence, and a sense of belonging in adolescents (Reiner et al., 2017). Peer support was also associated with lower odds of bullying both online and in person and sexual harassment in person for LGBT youth. Online friends were an important source of social support, while in-person social support had a protective effect on victimization (Ybarra, Mitchell, Palmer, & Reisner, 2015).

Peer interaction among adolescents could cause negative behavioural effects if they become attached to peers, demonstrating a pattern of misbehaviour. Young people's perception of the norms and values of their peers was strongly associated with their risk-taking and antisocial behaviours (E. Rice, 2010). Greater affiliation with misbehaving peers was associated with the early age of the first sex (Roche et al., 2005). In the context of Asia, premarital sex was associated with lack of confidence to resist peer pressure and the perception that more than half of their peers had engaged in sex (M. L. Wong et al., 2009). Those adolescents with online sexual partners and those who usually talked about drugs and partying were associated with an increased practice of sex exchange (S. D. Young & Rice, 2011).

Various studies confirmed that smoking, drug and alcohol use clearly depended on peer behaviour. A school-based sociometric study using adolescent health data showed that students with a greater portion of network ties with those who smoked were two times more likely to smoke as well and an extra two times more likely to smoke for those who had smoker as best friend (Alexander, Piazza, Mekos, & Valente, 2001; Thomas W. Valente, 2005). High school boys engaged in cigarette smoking and drug use to obtain peer acceptance (Alexander et al., 2001). Cross-sectional studies showed that high school students with peers who participated in illicit drug use or alcohol use were more likely to participate in these kinds of activities (Windle, 2020).

Adolescent perception of the behaviours of their peers plays a role in predicting their own behaviour. The perception that peers were sexually active predicted the sexual activity of the respondent (AOR= 1.32, 95% CI 1.11- 1.6) (Harrison et al., 2012). Baumgartner (2010) found that perceived peer involvement, perceived vulnerability, and perceived risks of risky sexual behaviours were associated with the sexual behaviours of adolescents (S. E. Baumgartner et al., 2010). Studies found that exposure based on the respondent's perceptions of their peer's behaviours was strongly associated with the respondent's behaviour (Thomas W. Valente, 2005).

Adolescent perceptions of their peers' behaviour were not consistent with their peers' actual behaviours. Disparities between perceptions and reported behaviours were significantly related to condom use, having multiple partners, having concurrent partners, sexual pressure, alcohol and drug use (Black, Schmiege, & Bull, 2013). Young women were more likely to report 'ever having had sex' when more friends were perceived to be sexually active (Elizabeth Fearon et al., 2019). Adolescents who used explicit Internet material and social network sites thought that their peers approved their sexual behaviours. These kinds of assumptions resulted in adolescents being sexually active in the follow-up survey (Suzan M. Doornwaard, Bogt, Reitz, & Eijnden, 2015).

Adolescents assumed that their peers engaged in certain behaviours that their peers actually did not engage in (E. Rice et al., 2010). Perceived peer norms favoring sex increased the odds of having multiple partners in Ghanaian male adolescents from Ghana (Bingenheimer et al., 2015). Adolescents who had exposure to online photos of partying and drinking by a friend were significantly associated with smoking and alcohol use among these adolescents (Huang et al., 2014). For boys, stronger perceptions that peers engaged in sex predicted an increased sex experience in the following months. Interestingly, adolescents who used explicit Internet materials and social networking sites were more likely to inflate their perceptions of peers approving sexual behaviour and their estimates on the number of sexually active peers (S. M. Doornwaard, Ter Bogt, Reitz, & Van Den Eijnden, 2015).

Influence of non-peers on adolescents' sexual behaviours

Having non-peers in the social network would trigger adaptation of non-peers behaviours in adolescents. The 'group norms' concept of Valente (2010) would apply here. Groups have norms that

its members follow. If a new person joins the group, he or she must accept these norms. The existing group members may pressure or persuade the new member to adopt these norms (Thomas W Valente, 2010).

Studies showed that having unknown adults in the network was associated with negative experiences for adolescents. Sklenorva (2018) studied a sample of German adolescents to compare social solicitations from adults and peers. He found that 2.6% of those who reported online social interaction with peers reported negative experiences, while 10.4% of those who reported online interaction with adults reported negative experiences (Sklenarova et al., 2018). A study in Spanish adolescents revealed that 17.2% reported online grooming by adults (Gassó, Klettke, Agustina, & Montiel, 2019). Younger men who had older members in their network were associated with concurrent sexual encounters (Yamanis et al., 2016).

The social network compositions of LGBT adolescents that include older friends can turn their sexual encounters into risky behaviours. LGBT adolescents reported that having friends older than the respondents was associated with an increased sexual risk (Finneran & Stephenson, 2014). The younger inexperienced followed the older and more experienced partners due to their ability to act as a role model and influence, particularly in settings where sociocultural norms promote that younger people had to respect older persons (Lin & Van der Putten, 2015). Furthermore, a study of Canadian adolescent MSM, of which 75% were Caucasian, who had older partners, were more likely to report condomless sex with sero-discordant or unknown status (Closson et al., 2017).

Having family members in the network and adolescents' sexual behaviours

Previous studies showed that adolescents were safe when family members were in their networks. Risky sexual behaviour was negatively associated with family connectedness (AOR= 0.39, 95% CI 0.3-0.51)(Handebo et al., 2018). Higher levels of family involvement prevented early sexual activity among adolescents and increased the likelihood of using contraception during sexual experiences (Majumdar, 2006). Family factors of adolescents have an impact on their sexual behaviours (Gutierrez Fernandez et al., 2010). Having family members in the network was also associated with reduced participation in risky sexual behaviours and substance use (Tyler, 2008).

Importance of network closeness (connectedness) in influencing sexual behaviours of adolescents

Closeness (connectedness) is similar to the nature of the tie strength, although the latter is calculated mathematically. Some previous studies used variables similar to the concept of closeness and found that the connection between adolescents and their network members prevented adolescents from engaging in risky sexual behaviours.

Risky sexual behaviour was negatively associated with family connectedness (AOR= 0.39, 95% CI 0.3-0.51)(Handebo et al., 2018). The interaction between friends increased the likelihood of using contraception during sex. It also reduced the odds of having sex before the age of 14 significantly by 5% (Majumdar, 2006). School connectedness was associated with lower odds of sexual activity (OR= 0.91) (Foster et al., 2017). A medium level of school connectedness was also a factor associated with the delay in premarital sex (OR = 0.27) in Vietnam (Le Linh & Blum, 2009).

Interestingly, if partners were connected with the friends and family members of the respondents, the rate of condom used was low due to a high level of trust. The closeness of social networks in family

and friend networks predicted a lower use due to the greater intimacy in adolescent dyads. Social network closeness was measured by the extent to which friends and family members of the respondents knew the sexual partner of the respondent (Aalsma, Fortenberry, Sayegh, & Orr, 2006).

Demographic status of the respondent and sexual behaviours

The age, sex, and socioeconomic status of adolescents contributed to the sexual behaviour of adolescents. Adolescents had sex more for emotional reasons compared to adults. Adolescent girls engaged more often in sex to express their emotions than older girls (Wyverkens et al., 2018).

Adolescent MSM were more likely to engage in risky sexual behaviours than adult MSM. Young age (16-25 years) MSM from the UK were less likely to have tested for HIV compared to adult MSM (Dalrymple, McAloney-Kocaman, Flowers, McDaid, & Frankis, 2019). In LGBT youth, a one year delay in the age of first exposure to sexually explicit material resulted in a 3% decrease in the odds of condom-less anal sex (Perry, Nelson, Carey, & Simoni, 2019). The misuse of information and cyber bullying was more common in younger MSMs. Younger respondents were more likely to refuse condoms in sex due to the sense of separation from the partner during sex (Lin & Van der Putten, 2015). Interestingly, young Australian MSM (18-29 years) were more likely to report their intention to have sex with a new partner only if a condom was available compared to adult MSM (Cheng et al., 2018).

The gender of adolescents affects their sexual behaviour differently. Boys were significantly more likely than girls to report sexual activity (37.7% vs 13.8%) in rural South Africa (Harrison et al., 2012). The sexual experience of the LGBT adolescents was unique in their own way. LGBT people in 44 European countries found that victimization for being homosexual was still high and was negatively associated with life satisfaction (Petrou & Lemke, 2018). Among LGBT, bisexual adolescents were more likely to conceal their sexual orientation, resulting in a weaker sense of community (LGBT), poor mental health outcomes, and more adverse health outcomes (Shilo & Mor, 2015).

One study found that the majority of adolescents enjoyed online sexual activity and half of the sample was cruising for sex online (Shilo & Mor, 2015); whereas another study reported that 87.5% of the sample enjoyed sexting (Bauermeister et al., 2014). The use of online LGBT community forums is associated with both positive and adverse effects in LGBT adolescents. The search for sex online is associated with positive effects such as a high level of 'outbreak', increased friend support, and greater connection to the gay community (Shilo & Mor, 2015). LGBT adolescents who reported having LGBT identified friends in their network and having others aware of their sexual orientation were associated with decreased sexual risks (Finneran & Stephenson, 2014).

On the other hand, the search for sex online was found to be a predictor of sexual risk behaviours. The search for online sex in LGBT adolescents was associated with having a higher number of partners (Shilo & Mor, 2015). Those involved in sexting were more likely to report anal intercourse with or without a condom than those who did not engage in sexting (Bauermeister et al., 2014). A cross-sectional study conducted in a Jewish community in Israel reported that those who seek sex online, presenting a high level of outness, and connectedness to the LGBT community, were associated with an increased incidence of sexual risk behaviour (Shilo & Mor, 2015).

Socioeconomic status was also a factor that affected the sexual behaviour of adolescents. In a Brazilian study on the sexual behaviour of pregnant adolescents, adolescents from low family income did not use the birth control method. Pregnancy was a reason for school evasion (Menezes, Delmondes, & Vieira, 2016). It was also found that acquisition and reinfection with sexually transmitted diseases

among young African-American women were related to their low socioeconomic situation (Sales et al., 2014).

2.5 Current research

This research aims to map the pathways in which young people's use of social media could support or undermine their healthy sexual development.

This research questions were as follows.

1. What pattern of interactions occurs within the social networks of adolescents?
2. Is there an association between the properties of the network and sexual behaviour of adolescents, and if so, what kind of association exists?
3. What variables of people constitute the networks of adolescents and is there any association between the variables of people in the network and sexual behaviour of adolescents, and if so, what kind of association exists?
4. How do social network attributes associate with sexual behaviours of adolescents, positively or negatively, and what is the extent of these associations?

We hypothesize as follows:

H1: Network level: Adolescents who have high personal network density; and particularly those who are from well-connected networks, would experience healthy sexual development.

H2a: Actor level: Adolescents who have a higher degree of centrality (i.e., have many people in the network) practice significant risky sexual behaviours.

H2b: Actor level: Adolescents who have a high brokerage role (very central in the social network and can reach many others within their personal network) practice significant risky sexual behaviours.

H3: Tie level: Adolescents with strong ties with people in their social networks experienced healthy sexual behaviours.

3. Methodology

3.1 Research design

Data for this study were collected from adolescents aged 15-17 in Australia between August 2015 and December 2018. The project examined the relationship between social networks and the development of healthy relationships and sexual behaviours in adolescence. The study employed mixed methods of interdisciplinary longitudinal research in sexual health, adolescent development, social science, media and communication, and social networks.

The adolescents were followed for 18 months. Participants completed three surveys at the beginning of the study (baseline), approximately 10 months after the onset of the study (midline survey) and approximately 20 months after the onset of the study (end line survey) to discuss their demographics, sexual behaviours, and social networks.

The study framework focused on key domains of healthy sexual development: freedom from unwanted activity, understanding of sexual consent and ethical conduct, understanding of safety, agency, resilience, open communication, self-acceptance, awareness, and acceptance that sex is pleasure and competence in mediated sexuality.

In this study, we performed statistical analysis to assess the association between social networks and sexual behaviours. Our research aimed to map the various ways young people use social networks that may support or undermine healthy sexual behaviour.

Our research questions were as follows:

1. What pattern of interactions occurs within the social networks of adolescents?
2. Is there an association between the properties of the network and sexual behaviour of adolescents, and if so, what kind of association exists?
3. What variables of people constitute the networks of adolescents and is there any association between the variables of people in the network and sexual behaviour of adolescents, and if so, what kind of association exists?
4. How do social network attributes associate with sexual behaviours of adolescents, positively or negatively, and what is the extent of these associations?

3.2 Sampling and recruitment

Adolescents aged 15-17 years, living in New South Wales Australia at the time of recruitment and competent to provide informed consent, were eligible to participate in the study. This age group comprises the last three years of secondary school and at this age most young Australians start sexual activities and relationships (Christopher M Fisher, 2018) .

The recruitment of the participants took place through different sources: Family Planning New South Wales (FPNSW) clinics, social media sites, the NSW 2016 Adolescent Sexual Health Promotion Conference, and one independent school. For the recruitment of the FPNSW clinics, research brochures were displayed at the Ashfield, Penrith, and Newcastle FP clinics. For the recruitment of social media sites, paid advertisements on Facebook and Instagram were set up to attract prospective

participants. For one independent (private) school in Sydney, the researchers obtained permission from the school management to recruit participants, recruitment was then facilitated by distributing research flyers in the school.

A 20$ incentive gift card for the completion of each fortnightly diary was rewarded. It was a means of keeping participants in the study throughout the research period. The study coordinator closely followed up with the participants by SMS or email to share study updates and send reminders. Respondents were free to communicate with the research coordinator to address their questions at any time.

There were 86 participants at the baseline, 63 at the midline and 55 at the end of the survey. The retention rate was 64%. To review whether the retained sample size was sufficient or to consider the follow-up of lost participants, we calculated the adjustment factor (Kirkwood & Sterne, 2010). The adjustment factor was the constant to estimate the sample size that should have remained at the end of the study, based on the sample size at the baseline survey, or either way around. We calculated the adjustment factor for this sample size using the formula: Adjustment factor for X% loss= 100/ (100-X). In our analysis, we assumed that the percent of loss was around 40%. Therefore, the adjustment factor for the 40% loss was 100/ (100-40) =1.67. If we wanted to estimate the appropriate sample size at the beginning of the study, the sample size had to be multiplied by the adjustment factor 50 x 1.67= 84. In this analysis, the baseline sample size was 86, suggesting that the sample size at the baseline was sufficient to cover the loss of participants in our analyses.

3.3 Data collection and recording

There were two main components of data collection in the SNAP study:

1) Questionnaires (baseline, midline, and end line) that consisted of both quantitative and qualitative components.

2) 2-weekly diaries (quantitative component)

The baseline survey was conducted in early to mid-2016, midline survey was conducted after the 19th diary, and end line survey was conducted after the 40th diary in late 2017 to mid-2018.

In this study, we focus on the quantitative components of three surveys and the diaries to answer research questions.

Questionnaires

Baseline questionnaires (at the beginning of the study), midline (approximately 10 months after they completed the baseline), and end line (approximately 20 months after they completed the baseline) were conducted. The questionnaires included sociodemographic background, their social networks, the variables of people in their networks, and their sexual behaviours at the baseline survey. For sociodemographic, sexuality, relationships, and sexual behaviour, the survey tools were adopted from the National Survey of Australian Secondary Students and Sexual Health (A. Mitchell, 2014). Demographic variables consisted of gender identity, age, country of birth, ethnicity, job status, and postal code of their home; education: self-reported school attendance, academic performance, and satisfaction at school; family matters: family and household composition, parents' education, and parents' employment.

Questions about social networks were developed based on the egocentric social network methodology advocated by Burt (2013) (Ronald S. Burt, Kilduff, & Tasselli, 2013). In this approach, the data from social networks were collected from the perspective of the respondent. The respondents were asked to recall all the interactions between themselves and their friends, as well as the interactions between alters and themselves from their perspective. The name generator question was 'Looking back over the last six months, list 5 to 10 people (e.g. friends, boyfriend/girlfriend, family member, etc.) with whom you interacted with most (called alters in the terminology of social networks)'. The respondents then further described the gender, first name, first initial of surname, occupation, type of relationship with the participant, data on the tie (e.g., frequency of interaction, and closeness to the alters). The respondents also provided information on which of the friends interacted with each other and how close they were to each other.

In terms of sexual behaviour, participants were asked their sexual attraction if they were attracted only to the opposite sex or both sexes, and what type of sexual activity they had had (e.g.; deep kissing, touching someone sexually, being touched sexually, giving oral sex, receiving oral sex, vaginal sex or anal sex). Then the respondents further described their age of first vaginal sex, age of first anal sex, and age of first sex without condom. For sex without a condom, they were asked: 'Have you ever had sex without a condom?' For the number of partners, they were asked: 'How many people have you had sex (vaginal or anal) with in the last six months?' For unwanted sexual experiences, they were asked: "Have you ever had sex when you didn't want to?"

At the midline and end line questionnaires, questions about the variables of the social network and variables of alters were repeated for each participant.

Diaries

Electronic 'diaries' were maintained biweekly in the format of a short questionnaire that captured participants' social network interactions and sexual behaviour during the preceding two weeks. The participants gave responses to the same questions 'diaries' during the 18 months of the research period. Participants received two reminder SMSs if they did not complete their diary. These diaries were managed by the secure survey data management system Redcap hosted by the University of Sydney. The diary questions were adopted from a validated scale used to measure on-line sexual risks created by Vannier and O'Sullivan (2010).

Diaries asked about social networks of the participants: to nominate five alters with whom they interacted with in the last two weeks. However, the diary questions did not cover details about the interactions between alters as did the questions in the three questionnaires (baseline, midline and end line). Therefore, the social network data from the diaries were not used in the cross-sectional analysis.

The sexual behaviour questions in the diaries covered the number of sexual partners in the preceding two weeks, if the sexual partners were boyfriend or girlfriend, the gender of the sex partner(s), whether the partners were casual or regular sex partners, the frequency of sex with that partner in the past two weeks and the average episodes of sex with a condom during sex in the past two weeks.

If the participant was sexually active, additional questions asked were about their most recent sexual activity in the past two weeks; how much the respondent wanted to have sex with that person and how enjoyable it was to have sex with that person. Responses to these two questions were in the format of sliding scales and participants had to slide to whatever rating most fitted their opinion on a scale out of 1 to 10, with 1 not at all while 10 very much.

Both questionnaire and diary data were managed via the Redcap data management program of the University of Sydney to ensure integrity, as well as confidentiality. The Redcap data files were password protected and only authorised persons had access to the data. During the analysis phase, all data analysis files were saved to a password protected maintained by Sydney University.

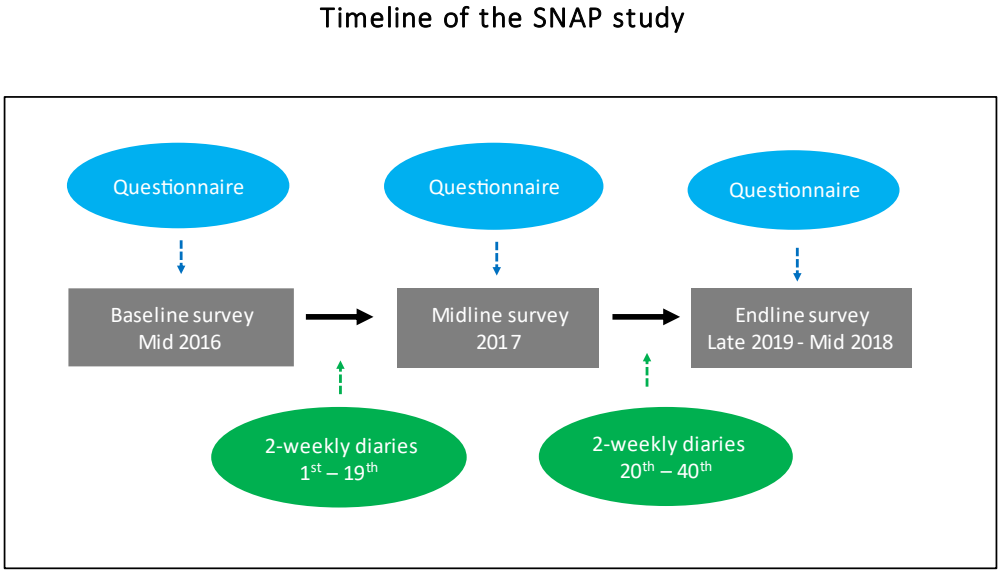


Figure 3-1 Timeline of the SNAP study

3.4 Data analysis

There were five stages in the analysis of the data:

1) Data preparation: This was the very first step, which involved cleaning the raw data, checking for data consistency, and creating categories.

2) Descriptive analysis: This served to understand the demographic attributes and attributes of social networks of the study population.

3) Social network analysis: This was used for each participant and was facilitated by using the UCINET social network analysis software.

4) Cross-sectional analyses: This was carried out to assess the association between (1) social network variables and participants' sexual behaviour and (2) alters' variables and participants' sexual behaviour. To assess the association between social network variables and sexual behaviours variables, we conducted three cross-sectional analyses: baseline, midline, and end line. We did this by running bivariate logistic regression and multivariate logistic regression for cross-sectional analyses.

5) Longitudinal analysis (trend analysis): Finally, a longitudinal analysis was performed to assess the prospective association between variables in the social network and the subsequent sexual behaviour of adolescents and the association between alters' variables and the sexual behaviours of adolescents.

This analysis facilitated learning about changes in sexual behaviour in the participants across time points. The GEE approach was applied for the longitudinal data analysis.

For the descriptive analysis and the regression analyses, we used the STATA version 13 software. We then triangulated the results of the cross-sectional and the longitudinal analysis. Each analysis will be explained in the following sections.

Data preparation

We checked the range and distribution of each variable by drawing a histogram and explored outliers. We also tested the consistency of the data using the scatter plot between two variables, e.g., vaginal sex status vs. the frequency of condom used.

To decide which model we should select between the linear regression model and logistic regression model, we drew the scattered plot, checked the regression line, and the correlation coefficient of the numerical exposure variables and numerical outcomes. The zero-correlation coefficient meant exposure and outcome variables did not associate and 1 meant highest correlation. There must be a strong correlation between exposure and the outcome variable to run linear regression models (Kirkwood & Sterne, 2010). In our data, some of the exposures did not show a strong linear relationship with respect to the correlation coefficient. Therefore, we decided to run the logistic regression model.

We collapsed the continuous variables into categorical variables for the logistic regression model. In theory, the categorical variable was created using the threshold value if it was available in previous studies. However, threshold values were not performed in previous publications, especially for the association of social networks variables and sexual behaviours variables of adolescents; and the association of variables of the alters and sexual behaviours of adolescents since these approaches were very novel. As we did not have threshold values, we decided to choose the cut-off point from the median or mean value of the variable data.

To test the cut-off value between the median and mean of the variables, we checked if the variables showed a normal distribution (Gaussian distribution). We drew the histograms and found that some of the variables presented a skewed distribution, and some variables showed a wide range between the maximum value and the minimum value and outliers. Therefore, we decided to use the median value as the threshold value to divide the numerical variables into categorical variables. Hypothesis testing was carried out using likelihood ratio tests to validate that our categorization did not affect the association of exposure and outcome. We also collapsed similar strata for some categorical variables in the SNAP study because some strata had only a few responses. However, this was done with caution to avoid misclassification errors.

Measures

There were three types of exposure variables: (1) demographic variables, (2) social network variables (3) Alters' (people in the networks of the respondent) variables. We created some variables, such as social network variables, based on the information from the SNAP study questionnaires. We also re-categorized some variables where needed, but we kept most as these were original categories in the SNAP study. The categories of the variables were created into high and low categories by the median value for each variable. The re-categorization of variables are presented in the table 3-2.

Demographic variables

Demographic variables were age, gender, sexual attraction, socioeconomic index for area (SEIFA)[1], place of birth, school status, education, school performance, job status, education of father, employment status of father, education of mother and employment status of mother.

Age: That was collapsed into two categories: (1) under 16 years and (2) 16 years.

Gender: This included (1) male, (2) female, and (3) other (kept as the original category from the data collection).

Sexual attraction: That was collapsed into (1) attracted only to people of the opposite sex and (2) attracted to people of the same sex or both sexes or others.

Socioeconomic index for area (SES) or Socio-Economic status (SES): In the original data collection, the postcodes of the and addresses of the respondents were recorded. An SES was created, based on the postcode and the information from the website of the Australia Bureau of Statistics. Then, SES was categorised into (1) 81.5 or less and (2) above 85.

Place of birth: This was classified as (1) yes, born in Australia; and (2) no (kept as the original category from the data

School status: This was classified as (1) year 12, (2) year 11, and (3) year 10 (kept as the original category from the data collection).

School performance: This was collapsed into (1) excellent/very good and (2) good or below average

Job status: This was collapsed into (1) no, I don't have a job and (2) yes, I work for payment or unpaid job.

Education of the father: This was collapsed into (1) university and (2) TAFE, high school, did not complete high school, or not sure.

Employment status of father: This was collapsed into (1) working full time; and (2) working part-time, unemployed, on a disability pension, studying, doing unpaid work inside the home, or not sure.

Education of mother: That was collapsed into (1) university (2) TAFE, high school, did not complete high school, or not sure.

Employment status of mother: This was collapsed into (1) working full time and (2) working part-time, unemployed, on a disability pension, studying, doing unpaid work inside the home, or not sure.

Social network variables

[1] Socio-Economic Indexes for Areas (SEIFA) is an Australian Bureau of Statistics's product that ranks areas in Australia according to relative socio-economic advantage and disadvantage. The indexes are based on information from the five-yearly Census of Population and Housing. The census variables used cover a number of domains and include household income, education, employment, occupation, housing and other indicators of advantage and disadvantage. Combined, the indexes provide more general measures of socio-economic status than is given by measuring one of the domains in isolation. SEIFA consists of four indexes: Index of Advantage/disadvantage, Index of disadvantage, Index of economic resources, Index of Education and Occupation

The variables of social network that we selected were degree centrality, betweenness centrality, efficiency, constraint, average tie strength, and ego density. The details of social network analysis will be explained in the following session.

Alters' variables

We were interested in the variables with respect to the relationship with the participant, the occupation of alters', and the closeness of the alters to participants. We selected variables that could explain these factors. For the relationship to the respondent, we chose the variables (1) number of friends in the network, (2) having boyfriend/girlfriend in the network, and (3) having family members in the network. For the occupation of the alters, we selected the variables (1) the number of high school students (2) having university students in the network, and (3) having nonstudents in the network. For closeness to the respondent, we chose the variables (1) the number of very close people in the network, (2) the number of close people in the network, and (3) the number of not really close people in the network.

In terms of type of people:

The number of friends in the networks: This was a numerical value in the baseline, midline, and end-line surveys of the SNAP study. The responses were classified into (1) five friends or fewer friends in the networks and (2) more than five friends in the networks. These categories were similar for all three surveys; baseline, midline, and end line, because the median values were similar across these three time points.

Having a boyfriend/girlfriend on the network: This was a numerical value in the SNAP study baseline, midline and end line surveys. Responses were categorised into: (1) No boyfriend/girlfriend in the networks and (2) Yes, there was a boyfriend/girlfriend in the networks. These categories were similar for all three surveys: baseline, midline, and end line.

Having family members in the network: This was a numerical value in the SNAP study baseline, midline and end line surveys. We categorised responses into: (1) no family members in the networks and (2) there are family members in the networks. These categories were similar for all three surveys: baseline, midline and end line.

In terms of occupation of the alters

Having high school students on the network: This was a numerical value in the SNAP study baseline, midline and end line survey. We categorised the responses into (1) 1-5 high school students in the networks and (2) more than five high school students in the networks for the baseline survey. The number of high school students declined across the midline and end line survey. Therefore, we categorised it into (1) 1-4 high school students in the networks and (2) more than four high school students in the networks for the midline survey; and (1) no high school students in the networks and (2) one or more than one high school student in the networks for the end line survey.

Having university students in the network: That was a numerical value in the SNAP study baseline, midline and end line surveys. We categorised responses into: (1) no university student in the networks and (2) there are university students in the networks. These categories were similar for all three surveys; baseline, midline and end line because the median values were similar across three time points.

Having non-student workers in the network: That was a numerical value in the SNAP study baseline, midline and end line surveys. We categorised responses into (1) no non-student workers in the networks and (2) one or more non-student workers in the networks for the baseline survey. These categories were similar for all three surveys; baseline, midline and end line, because the median values were similar across three time points.

In terms of closeness to the respondent

Having 'very close' people in the network: That was a numerical number in the baseline, midline, and end-line surveys of the SNAP study. We categorised responses into: (1) less than three very close people in the networks and (2) three or more than three very close people in the networks for the baseline survey. These categories were similar for all three surveys; baseline, midline and end line, because the median values were similar across three time points.

Having 'close' people in the network: That was a numerical value in the SNAP study baseline, midline and end line surveys. We categorised the responses into: (1) less than three close people in the networks and (2) three or more than three close people in the networks for the baseline survey. These categories were similar for all three surveys; baseline, midline and end line, because the median values were similar across three time points.

Having people 'not really close' in the network: That was a numerical value in the SNAP study baseline, midline and end line surveys. We categorised responses into: (1) no person is not really close in the networks and (2) one or more people are not really close in the networks for the baseline survey. These categories were similar for all three surveys; baseline, midline and end line, because the median values were similar across three time points (Table 3-1).

Table 3-1 Alter's variables

	Variable	Baseline survey	Midline survey	End line survey
	Type of people in the network			
1	Number of friends in the network	(1) five friends or fewer friends in the networks (2) more than five friends in the networks.	(1) five friends or fewer friends in the networks (2) more than five friends in the networks.	(1) five friends or fewer friends in the networks (2) more than five friends in the networks.
2	Having boyfriend/girlfriend in the network	(1) No boyfriend/girlfriend in the networks (2) Yes, there was a boyfriend/girlfriend in the networks.	(1) No boyfriend/girlfriend in the networks (2) Yes, there was a boyfriend/girlfriend in the networks.	(1) No boyfriend/girlfriend in the networks (2) Yes, there was a boyfriend/girlfriend in the networks.
3	Having family members in the network	(1) no family members in the networks (2) there are family members in the networks	(1) no family members in the networks (2) there are family members in the networks	(1) no family members in the networks (2) there are family members in the networks
	Occupation of the people			
4	The number of high school students	(1) 1-5 high school students in the networks (2) more than five high school students in the networks	(1) 1-4 high school students in the networks (2) more than four high school students in the networks	(1) no high school students in the networks (2) one or more than one high school student in the networks
5	Having university students in the network	(1) no university student in the networks (2) there are university students in the networks	(1) no university student in the networks (2) there are university students in the networks	(1) no university student in the networks (2) there are university students in the networks
6	Having nonstudents in the network	(1) no workers in the networks (2) one or more workers in the networks	(1) no workers in the networks (2) one or more workers in the networks	(1) no workers in the networks (2) one or more workers in the networks
	Closeness to the respondent			
7	The number of very close people in the network	(1) less than three very close people in the networks (2) three or more than three very close people in the networks	(1) less than three very close people in the networks (2) three or more than three very close people in the networks	(1) less than three very close people in the networks (2) three or more than three very close people in the networks
8	The number of close people in the network	(1) less than three close people in the networks (2) three or more than three close people in the networks	(1) less than three close people in the networks (2) three or more than three close people in the networks	(1) less than three close people in the networks (2) three or more than three close people in the networks
9	The number of not really close people in the network.	(1) no person is not really close in the networks (2) one or more people are not really close in the networks	(1) no person is not really close in the networks (2) one or more people are not really close in the networks	(1) no person is not really close in the networks (2) one or more people are not really close in the networks

Outcome variables

The outcome variable we interested were vaginal sex status, anal sex status, age of first vaginal sex, age of anal sex, age of first sex without condom, number of sexual partners, type of sexual partners, sex without a condom, episodes of sex with a condom in the past two weeks, experience of unwanted sex in life, wanting sex and enjoying sex. We modified these outcomes from the SNAP study to be more compact variables, numerical to categorical variables, or categorical variables to binomial variables (Table 5-2).

Table 3-2 Outcome variables

	Variable	Original data	New categories	Data source from SNAP study	Study
1	Vaginal sex status	(1) no (2) yes	(1) no (2) yes	Baseline survey and the fortnightly diaries	Descriptive study
2	Anal sex status	(1) no (2) yes	(1) no (2) yes	Baseline survey and the fortnightly diaries	Descriptive study
3	Age of first vaginal sex	Numerical variable	(1) under 16 years of age (2) 16 years of age and above*	Baseline survey	Descriptive study
4	Age of anal sex	Numerical variable	(1) under 16 years of age (2) 16 years of age and above*	Baseline survey	Descriptive study
5	Age of first sex without condom	Numerical variable	(1) under 16 years of age (2) 16 years of age and older	Baseline survey	Descriptive study
6	Number of sexual partners	(1) number of sexual partners in the past six months	(1) one partner in the last six months (2) more than one partner in the preceding six months	Baseline survey	Baseline cross-sectional analysis
		(2) number of sexual partners in the past two weeks	(1) one partner in the preceding two weeks (2) more than one partner in the preceding two weeks	Fortnightly diaries	Midline and end line cross-sectional analysis and longitudinal analysis
7	Type of sexual partners	(1) regular only (2) regular and casual (3) casual	(1) regular only (2) regular and casual	Fortnightly diaries	
8	Sex without a condom	(1) yes (2) no	(1) yes (2) no	Baseline survey	
9	Episodes of sex with a condom during the past two weeks	Numerical variable	(1) no condom during the past two weeks (2) on average one or more episodes of sex with a condom during the past two weeks		

	Variable	Original data	New categories	Data source from SNAP study	Study
10	Experience of unwanted sex in life	(1) yes (2) no	(1) yes (2) no	Baseline survey	
11	Wanting sex	Numerical scale a score 1-10 for each sexual partner, 1 meant that no one wanted to have sex with that person while 10 meant that they very much wanting sex with that person.	(1) less than 85 and (2) 85 and above **	Fortnightly diaries between baseline and midline surveys	Midline cross-sectional study
			(1) less than 85 and (2) 85 and above **	Fortnightly diaries between midline and end-line surveys	End-line cross-sectional study
12	Enjoying sex	Numerical scale in the SNAP study diaries with a score 1-10 for each sexual partner, 1 meant not enjoyable while 10 meant very enjoyable	(1) less than 75 (2) 75 and above **	Fortnightly diaries between baseline and midline surveys	Midline cross-sectional study
			(1) less than 80 (2) 80 and above **	Fortnightly diaries between midline and end-line surveys	End-line cross-sectional study

*Here, we use a cutoff value of 16 for age because many of Australia's adolescents were reported to become sexually active at this age.(Christopher M Fisher, 2019)

**Cut-off point- median value

Social network analysis

Definition of social network variables

In this study, we focus on six social network variables we focus on: Degree centrality, Betweenness centrality, Efficiency, Constraint, Average tie strength, and Ego density.

Degree centrality

Degree centrality is the simplest property of a social network and comprises the number of ties the respondents have to their friends. It explains the information flow and influence.

The formula for degree centrality (Prell, 2011), for actor 1:

$$\mathrm{CD(i)} = \sum_{j=1}^{n} x_{ij} = \sum_{i=1}^{n} x_{ji}$$

x_{ji}= the value of tie from actor *i* to actor *j* (the value being 0 or 1). Thus, it is the sum of all ties. n= the number of nodes in the network.

The advantage of the degree-centrality measure is that it is easily interpretable in all kinds of networks. The disadvantage is that it is a crude measure of centrality and cannot provide more accurate information, such as the position of nodes in a network (Borgatti et al., 2013).

There is controversy in the measurement of degree centrality. Some researchers divided degree centrality into (1) in degree: the number of connections a person received in the network and (2) out degree: the number of connections a person sent to the network while some researchers counted degree centrality in general. The current study focused on the common degree, which was not defined as degree 'in' or out degree because we assumed that respondents and alters have both 'in degree' and 'out degree' in their ego networks.

Betweenness centrality

The centrality of Betweenness is the extent to which a respondent is on the shortest path to all the others in the network. In other words, it explains the brokerage capacity of someone. Those who have a brokerage position are privileged due to the novel information and creativity.

The formula for betweenness centrality (Prell, 2011) for actor k :

$$C_B\,(k) = \sum \partial_{ikj} / \partial_{ij}\,, i \neq j \neq k$$

∂_{ikj}= the number of geodesics that connect actors I and j that pass through node k

∂_{ij}= the number of geodesics that link actors i and j

Efficiency

Efficiency is a measure of brokerage that would explain if an individual could maximise the brokerage power in the networks by bridging nonconnected groups. Efficiency is the total number of people reached with all primary individual contacts.

Efficiency in the network is the effective size/ network size.

The effective size is the average number of people reached per primary contact.

Network size is the total number of people in the network (if they were contacting each other, count the subgroup as one network).

The effective size of an actor's (ego) network is defined by Burt (2012) (Chung, 2009a) as:

$$\sum_{j} \left[1 - \sum_{q} p_{iq} \; m_{jq} \right], q \neq i, j$$

Where i is the ego, actor j is a primary contact and actor q is also a primary contact who has strong ties to ego i (represented by p_{iq}) and actor j (represented by m_{jq}).

Constraints

Constraint is a measure of the extent to which a network is tightly connected and, as a result, redundant information circulates in the network quickly.

The constraint on an actor's network is defined by Burt (1992) (Chung, 2009a) as:

$$\left[p_{ij} + \sum_{q} p_{iq} \; p_{qj} \right]^{2}, q \neq i, j$$

Where i is the ego, actor j is a primary contact, and actor q is also a primary contact who has strong ties to ego i (represented by p_{iq}) and actor j (represented by p_{qj}).

Ego density

Ego density refers to the density of the network rather than the respondent. In a simple term, it is how the friends of a respondent connect with each other.

The formula of Ego density for an ego network (with ego as actor 1):

$$d_i = \frac{L}{n\,(n-1)/2}$$

Where n refers to the number of alters to which the ego is connected, and L refers to the number of lines between the alters.

Average tie strength

Average tie strength is a measure of how frequently the respondent interacts with others in the network and how close they are to them within the network.

The strength of the tie according to Granovetter's theory was the frequency of contact, the reciprocity of services, and intimacy.

The tie strength is the combination of frequency of contact with each network member plus closeness score with each network member.)

Social network analysis at baseline

We used the UCINET social network analysis software. Before running the analysis, we re-coded the data because the software accepted 0 or 1 in the social network matrix to calculate the variables of the social network variables. In the Excel file, we created the variables: (1) social connection between ego and alter and (2) social connection between alter and alter.

Social Connection between Ego and Alter

This variable was created in the question: How close are you to Person 1? (Very close, close, not really close, not close at all). If the answer was very close, or close we coded that variable as 1 and if the answer was not really close or not close at all, we coded that variable as 0 for the social connection between Ego (the respondent) and person 1. We repeated this coding for all the ten social connections between Ego and Alter.

Social connection between Alter and Alter

This variable was created in the question: How close is person 1 to person 2? (They are very close, they are close, they know each other but are not close, they don't know each other or are unsure). We coded the variable as 1 if the answer was 'they are very close' or 'they are close' or 'they know each other but are not close'; and coded as 0 if they answered 'they don't know each other' or 'unsure'. This coding was repeated for person 1 (alter) and his/her 10 alters, then person 2 (alter) and his/her 10 alters, until person 10 (alter) and his/her 10 alters.

After creating these variables, we transferred the data set into the UCINET software for each participant and calculated the degree centrality, betweenness centrality, efficiency, the constraint and the ego density for each participant.

The average tie strength was calculated in an Excel spreadsheet using the mathematical formula. This formula combined the face-to-face interaction score and the closeness score. The score for face-to-

face interaction was based on the variable 'On average, how often do you interact with person 1 face-to-face'. (every day, several times a week, once a week, once a month, less than once a month, never)". A score of 5 was created for meeting face to face every day, 4 for several times a week, 3 for once a week, 2 for once a month, 1 for less than a month and 0 for never. The closeness score was based on the variable 'How close are you to person 1?' (very close, close, not really close, not close at all) '. A score of 3 was created for very close, 2 for close, 1 for not really close and 0 for not close at all. Then, the score for face-to-face interaction and the score for closeness were summed for each alter of a participant to arrive at a tie score between the participant and each alter. The tie scores of all alters of an ego were then summed and divided by the number of alters for each ego to arrive at an average tie strength score.

After the social network analysis, we arrived at six numerical social network variables for each participant. Then, these numerical variables were classified as high and low by the median value of each variable in the baseline data analysis.

Social network analysis at midline

The social network analysis procedure was repeated for the social network data from the midline survey. The numerical social network variables were then categorised as high and low by the median value of each variable in the midline data analysis.

Social network analysis at end line

The social network analysis procedure was repeated for the social network data from the end-line survey. The numerical social network variables were then classified as high and low by the median value of each variable in the end line data analysis.

Table 3-3 The categories of social network variables for the baseline survey, midline survey and end line survey data analysis

	Variables	Baseline survey	Midline survey	Endline survey
1	Degree centrality	(1) less than 8 (2) 8 to 10	(1) less than 8 (2) 8 to 10	(1) less than 7 (2) 7 to 10
2	Betweenness centrality	(1) less than 4 (2) 4 to 41	(1) less than 4 (2) 4 to 41	(1) less than 4 (2) 4 to 36.5
3	Efficiency	(1) less than 0.5 (2) 0.5 to 0.92	(1) less than 0.5 (2) 0.5 to 1	(1) less than 0.49 (2) 0.49 to 0.92
4	Constraint	(1) less than 0.4 (2) 0.4 to 0.64	(1) less than 0.4 (2) 0.4 to 0.65	(1) less than 0.5 (2) 0.5 to 0.9
5	Average tie strength	(1) less than 8.1 (2) 8.1 to 9.6	(1) less than 7.6 (2) 7.6 to 9.5	(1) less than 7.8 (2) 7.8 to 9
6	Ego network density	(1) less than 0.6 (2) 0.6 to 1	(1) less than 0.6 (2) 0.6 to 1	(1) less than 0.6 (2) 0.6 to 1

Cross sectional analyses

Baseline cross sectional analysis

We conducted a baseline cross-sectional analysis to assess the association between (1) demographic variables and sexual behaviour variables of adolescents (2) social network variables and sexual behaviour variables of adolescents and (3) alters variables and sexual behaviour variables of adolescents. The following demographic data were extracted from the baseline survey: age, gender, sexual attraction and SES.

The variables of the social network included degree centrality, betweenness centrality, efficiency, constraint, average tie strength, and ego density. The alters' variables developed from the baseline survey included: number of friends in the networks, having boyfriend/girlfriend in the networks, having family members in the networks, number of high school students in the networks, having university students in the network, having nonstudents in the networks, number of very close people in the networks, number of close people in the networks, and number of people not really close in the networks. The variables of sexual behaviour taken from the baseline survey included: vaginal sex status, anal sex status, age of the first vaginal sex, age of the first anal sex, age of first sex without condom, number of sexual partners in the past six months, experience of sex without condom in life and experience of unwanted sex in life.

Midline cross sectional analysis

We conducted a midline cross-sectional analysis to assess the association between (1) demographic variables and sexual behaviour variables of adolescents (2) social network variables and sexual behaviour variables of adolescents and (3) alters variables and sexual behaviour variables of adolescents.

Demographic data extracted from the baseline survey included age, gender, sexual attraction, and SES, because we assumed that these variables were less variable than other variables. Social network variables including degree centrality, betweenness centrality, efficiency, constraint, average tie strength, and ego density were calculated from data extracted from the midline survey.

Variables of the alters were developed from the midline survey and included: number of friends in the networks, having boyfriend/girlfriend in the networks, having family members in the networks, number of high school students in the networks, having university students in the networks, having nonstudents in the networks, number of very close people in the networks, number of close people in the networks, and number of people not really close in the networks.

The variables of the sexual behaviour variables were taken from fortnightly completed diaries of the participants between the baseline survey and the midline survey. Sexual behaviour between baseline and midline included: vaginal sex status, anal sex status, type of sexual partners, average episodes of sex with a condom per fortnight, average number of sexual partners per fortnight, average of how much the participant wanted sex per fortnight (score), and average how much the participant enjoyed sex per fortnight (score).

End-line cross sectional analysis

We conducted end-line cross sectional analyses to assess the association between (1) demographic variables and sexual behaviour variables of adolescents, (2) social network variables and sexual behaviour variables of adolescents and (3) alters' variables and sexual behaviour variables of adolescents.

Demographic data extracted from the baseline survey included age, gender, sexual attraction, and SES, because we assumed that these variables were less likely to change over time than other variables. Social network variables including degree centrality, betweenness centrality, efficiency, constraint, average tie strength, and ego density were calculated from data extracted from the end-line survey.

Variables of sexual behaviour were taken from the fortnightly completed diaries of the participants between the midline and end-line survey. Sexual behaviour between the midline and end line included vaginal sex status, anal sex status, type of sexual partners, average episodes of sex with a condom per fortnight, average number of sexual partners per fortnight, average How much the participant wanted sex per fortnight (score), and how much the participant enjoyed sex per fortnight (score).

Variables of the alters were developed from the end-line survey and included: number of friends in the networks, having boyfriend/girlfriend in the networks, having family members in the networks, number of high school students in the networks, having university students in the network, having nonstudents in the networks, number of very close people in the networks, number of close people in the networks, and number of people not really close in the networks.

Statistical tests applied for the cross-sectional analyses

In cross-sectional analyses, we used bivariate regression analysis. We tested the bivariate analysis to examine the association of the outcome with each exposure to find the crude association between these two variables only ignoring other variables.

Then we prepared the multiple regression model to compare the means of several groups that control the confounders. In the multiple regression model, there were two assumptions (1) that the outcome is normally distributed and (2) that the population value for the standard deviation between individuals is the same in each exposure group. To perform multiple regression, we tested whether the relationship between exposure and outcome was linear regression. Since some outcome variables did not show a normal distribution and linear association with the exposure outcome, we decided to run the multivariate logistic regression model. The p-value of 0.05 was applied to indicate statistical significance against the null hypothesis. The results of the bivariate analysis were presented together with the results of the multivariate analysis to observe the degree to which the crude estimate altered when certain confounders were controlled.

When we prepared the multiple logistic regression model using the Mantel and Haenszel methods (stratification), we considered including the confounders, i.e. the variable which could affect the association between exposure and outcome. We chose which variables could be confounders based on the literature review because external knowledge was reasonable to choose appropriate confounders in the multiple logistic regression model (Kirkwood & Sterne, 2010). We wish to include all the possible variables that would be associated with the outcome in the multiple logistic regression model. However, the sample size was not large enough to control all confounder variables in each

model (Martínez-Mesa, González-Chica, Bastos, Bonamigo, & Duquia, 2014). Therefore, it was decided to adjust the most important variables that were known to be associated with sexual behaviours of adolescents from the literature review such as age, gender and socio-economic status of the participants.

We also tested whether exposure and these confounder variables were highly correlated to identify collinearity. Moreover, we noticed that there could be an interaction between confounders or between a confounder and exposure of interest or between exposures of interest. However, the sample size in this study was not large enough to add interaction terms in the multiple logistic regression model (Kamangar, 2012; Luan, Wong, Day, & Wareham, 2001; Martínez-Mesa et al., 2014). Therefore, we treat confounder variables as confounders only.

Longitudinal analysis (trend analysis)

We tried to identify changes in sexual behaviour among adolescents throughout the research period comparing between groups with high social network properties and groups with low social network properties; as well as between the high and low category of each variable of alters (alter is a person who connected to the respondent). Exposure variables in terms of social networks were extracted from the baseline survey. Then, the categories of the exposure variables were created into high and low categories by the median value for each variable.

Table 3-4 The categories of social network variables for longitudinal data analysis

	Variables	Categories
1	Degree centrality	(1) 0 to 8 (2) Above 8
2	Betweenness centrality	(1) 0 to 4.17 (2) Above 4.17
3	Efficiency	(1) 0-0.52 (2) Above 0.52
4	Constraint	(1) 0 to 0.403 (2) Above 0.403
5	Average tie strength	(1) 0 to 8.1 (2) Above 8.1
6	Ego network density	(1) 0 to 0.6 (2) Above 0.06

The outcome variables were:

1. Number of sexual partners per fortnight
2. Episodes of sex with a condom used per fortnight
3. How much the participant wanted sex per fortnight (score)
4. How much the participant enjoyed sex per fortnight (score)

The outcome variables were taken from the fortnightly diaries throughout the research period from the baseline to the end-line survey. There were a maximum of forty diaries. The outcome variables were kept as numerical variables because we wanted to calculate the incidence rate ratio (IRR). To execute the time trends analysis, we create the outcome variables for two time points T1-T2 (diaries between the baseline and midline survey) and T2-T3 (diaries between the midline and end-line survey). For example, to calculate the average episodes of sex with a condom per fortnight between baseline and midline for a participant, we combined the episodes of sex with a condom per diary

(fortnight) of that person for all diaries between baseline and midline for that person and divided by the number of diaries in that period.

We analysed the IRR using the Poisson regression method. This method describes the number of occurrences of an event during a period if these events occur independently of each other and at random. It estimated the rate ratios by comparing different exposure groups in the same way that logistic regression did. It compared the rates between two exposure groups and examined the effect of categorical exposure variables. In our analysis, we compared the change in sexual behaviours in the high and low group across two time points: baseline to midline survey (T1-T2) vs midline to end line survey (T2-T3).

We calculated the IRR for the longitudinal analysis because the sexual behaviours were not rare and these changed over time. The incidence rate counted the number of new events related to the number at risk at the beginning of the observation period. We calculated the IRR that compared the incidence rates of sexual behaviours in the group with low social network variable vs. the group with high social network variable. We also calculated the incidence rates of sexual behaviours in the group with low alters' variable vs. the group with high alters' variable. In the generalised equation models, we did not include additional variables because it would tend to increase the standard error of the exposure effect estimate if the sample size was not large enough.

3.5 Summary of studies of the thesis

There are nine studies in this thesis. These are presented schematically within the SNAP study in Figure 3-2.

Study 1 provides an evaluation of the association between social networks and age of first sexual exposure in adolescents.

Study 2 is the descriptive study of demographic variables of the respondents, their sexual behaviours and social network variables, and the variables of the people in the networks of the respondents at the baseline, midline and endline surveys.

Study 3 tested the association between social networks and sexual behaviours of the respondents at baseline survey as a cross-sectional analysis.

Study 4 tested the association between social networks and sexual behaviours of the respondents at midline survey as a cross-sectional analysis.

Study 5 tested the association between social networks and sexual behaviours of the respondents at end line survey, respectively as a cross-sectional analysis.

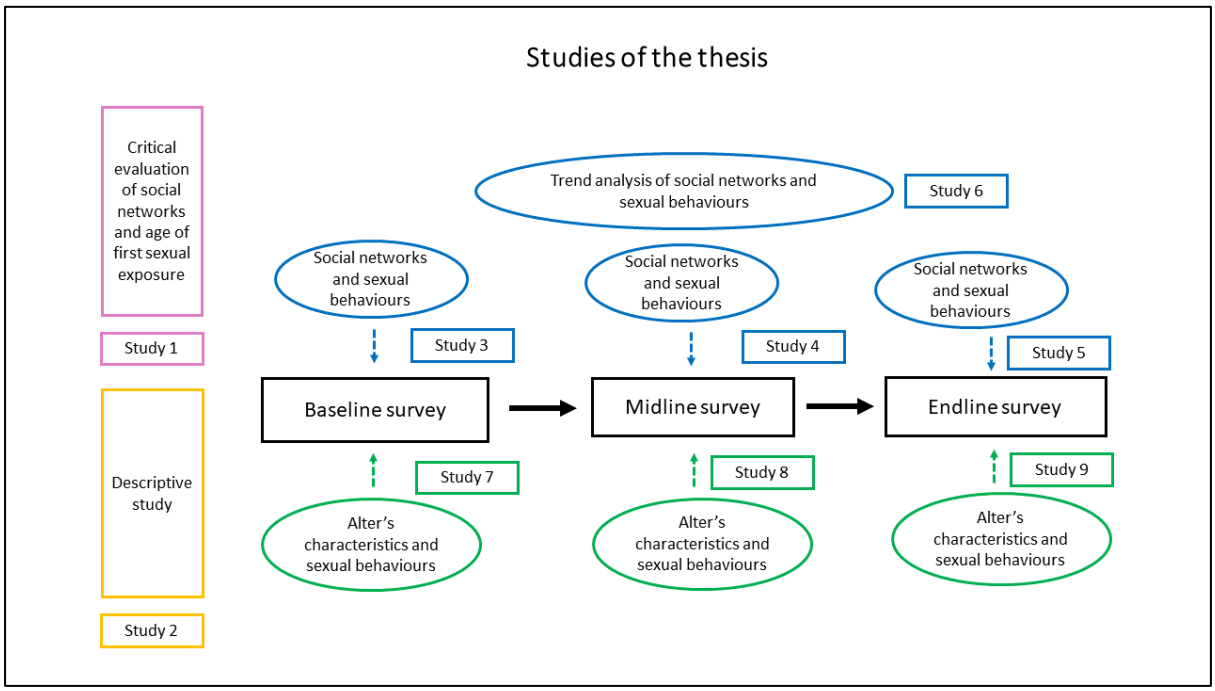
Study 6 explored the association between social networks and sexual behaviours of the respondents along the studies from baseline to midline survey (T1-T2) vs midline to end line survey (T2-T3) as the trend analysis.

Study 7 evaluated the association between alters variables and sexual behaviours of the respondents at baseline survey as a cross-sectional analysis.

Study 8 evaluated the association between alters variables and sexual behaviours of the respondents at midline survey as a cross-sectional analysis.

Study 9 evaluated the association between alters variables and sexual behaviours of the respondents at endline survey as a cross-sectional analysis.

Figure 3-2 Studies of the thesis



3.6 Ethical considerations

The University of Sydney Human Research Ethics Committee and the Family Planning New South Wales Ethics Committee granted ethical approval for this study.

4. Findings

Study 1: A systematic review and meta-analysis of social networks and age of first sexual exposure

Introduction

Social network and adolescents' health

There are many studies that highlight that peers had an impact on adolescents' health behaviours because the sense of belonging is important, as belonging stands for shared beliefs, needs, and outcomes. Alexander and colleagues learned that adolescents who had a close friend who smoked were two times more likely to smoke. Similarly, cross-sectional studies showed that high school students with peers who participated in illicit drug use or alcohol use were more likely to be involved in these kinds of activities. (Windle, 2020) High on sensation seeking youths searched for friends who were also high on sensation seeking and more likely to experience alcohol and other substance use and peer pressure was the most common reason for them to it difficult to refuse beer, marijuana, drug use, and cigarette smoking (Alexander et al., 2001).

Social network and sexual behaviours of adolescents

Most adolescents have access to a smartphone and a laptop computer. The internet has become an asset in their sexual life. Since exploring sexuality and building social relationships is part of an adolescent's life, the Internet plays a role for them to search for information and potential romantic and sexual relationships (Boies, Knudson, & Young, 2004). The Internet has been a part of young people's lives due to easy access, affordability, and perceived anonymity (Cooper, 1998). The 2018 National Survey of Secondary Students and Sexual Health Australia 2018 which included 6,327 students, found that most of the students were active and frequent users of social networks. One third of the students reported 'sexting' in the last two months, mostly with a girlfriend, boyfriend or friends. More than half had done so a few times in the last two months. The most common experience of online sexual behaviour was receiving a sexually explicit written text message (50.7%) and sending a similar message (40.4%) (Christopher M Fisher, 2019). Some studies criticised online social networks for pushing adolescents to engage in risky sexual behaviours. A study conducted in Germany in 2019 found that youth using dating apps reported more risky sexual behaviours than non-users (Tomaszewska & Schuster, 2019). Similarly, evaluating online relationships identified teens to face higher sexual risk.(Lerman & Bleakley, 2015) Moreover, offline social networks like friends were also influential on the sexual behaviours of young women (E. Fearon et al., 2019).

Social network and adolescents' sexual initiation

Kirby (2002) compiled the antecedents of adolescent initiation of sex and found a variety of factors that enhance or inhibit the sexual initiation of adolescents. Having older age peers and close friends, having peers with poor grades and high non-normative behaviour, peers with lower achievement orientation, peers who drink alcohol, and peers with permissive attitudes towards premarital sex, and sexually active peers were associated with early initiation of sex. The higher quality of family interactions, connectedness, greater parental child communication about sex, and birth control were associated with late initiation of sex. Those with a greater connection to school and those with greater school attendance were more likely to have late initiation of sex (Kirby, 2002). Offiong (2019) also explored the factors associated with early sex onset in urban young men and found that older partners

and weak parental relationships were associated with early onset of sex (Offiong et al., 2019). Peer group norms also had an important effect on the timing of sexual initiation in both boys and girls (Richards-Shubik, 2015). However, there is no particular systematic review on the association between social networks and first sexual exposure of adolescents. The present review will fill that gap by exploring which kind of social network interaction would modify the first sexual experience of adolescents through a systematic review.

Methods

This review posed the question as to whether there is evidence that certain types of social networks are associated with having an earlier age of first sexual experience or early sexual debut in life compared to young people who are less exposed to these. This systematic review and meta-analysis followed the guidelines Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher, Liberati, Tetzlaff, Altman, & The, 2009; Shamseer et al., 2015).

Search strategy

We searched the bibliographic databases Medline, Embase, PsycINFO and Web of Science until 26 January 2022 using the following search terms (and variations) for both keyword and subject headings for terms describing the concept 1: Social network, Online social networking, Internet, Social Media, Facebook or Twitter, Social communication, Degree, Closeness, Betweenness, Indegree, Outdegree, Tie, Ego density, Efficiency, and Constraint; concept 2: Adolescent, Teen, Young and Juvenile and Concept 3: Sexual debut, First sex, First intercourse, Coitus, Sex activity, Launch sex, and Virgin (Appendix); both in subject headings and keywords. We also reviewed the references from the articles and searched our personal archives to identify additional studies.

Inclusion criteria

We included the studies if they 1) studied adolescents aged 10-24 years (Definition of adolescents by the Lancet Commission of Adolescent Health) (Patton et al., 2016b) ; 2) studied the association between exposure of any kind of social network and first sexual exposure or early sexual debut. Social networks can be online or offline social networks. Social networks included social media: Facebook, Twitter, Tumblr, Instagram, Linked-in, WeChat, blogs, and dating apps and social network attributes such as: Degree centrality, Closeness centrality, Tie strength, Ego density, Efficiency and Constraint. Offline social networks included in person relationships such as: family, friends, and colleagues. The first sexual experience included: ever having sex, first sexual exposure, first sexual experiences, and premarital sex of adolescents. The early sexual debut embraced various definitions of the early sexual debut of the original authors.

Exclusion criteria

A study was excluded if it did not report the association between exposure of any kind of social network and the first sexual exposure of adolescents; did not provide complete findings (conference abstracts); did not contain primary data (review articles); did not observe the natural association of exposure and outcome (i.e. experimental studies); did not test the main exposure and outcome (i.e. studies which explored the validity of the tools) and studies published in a language other than English.

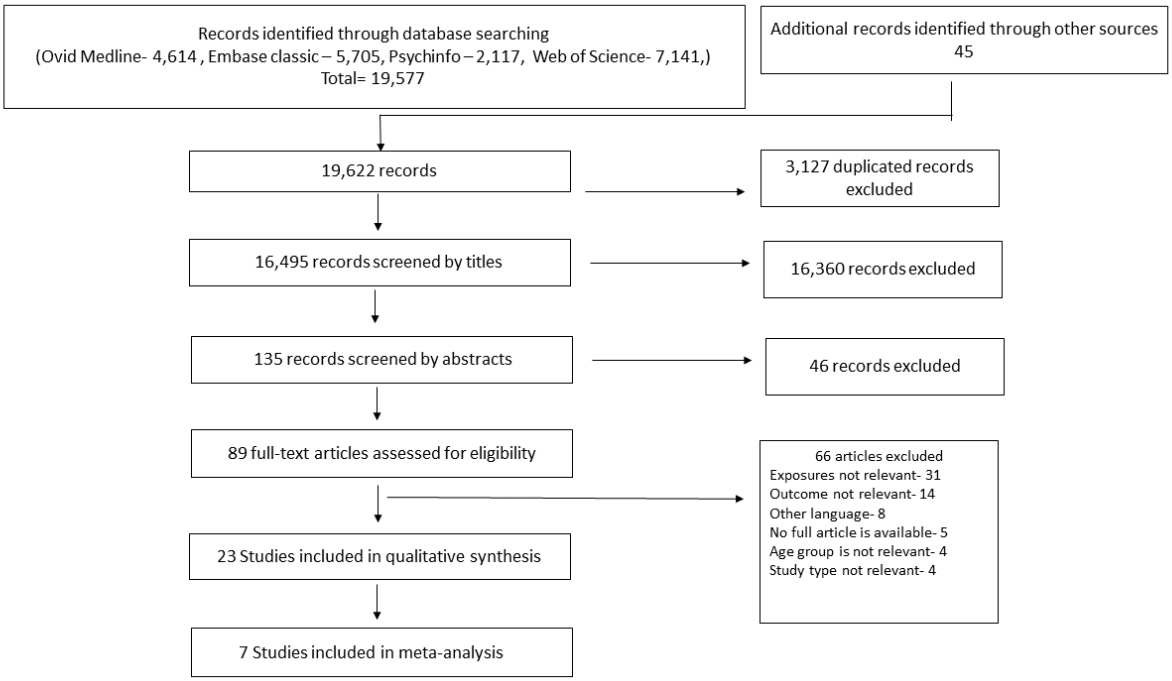


Figure 4-1 Overview of literature search

Data extraction and management

All articles obtained from the databases by search terms were exported to Endnote. After removing duplicate articles, the first author selected the title and abstract of the articles as a first step. After the first screening, the full text of the articles was reviewed according to the inclusion criteria. If the first author could not decide if the article was relevant at the full-text phase, he discussed with coauthors to get a consensus.

We used a standardized data extraction form to obtain data on the study design and other relevant results. Data were mainly extracted by the first author and then cross-checked by the coauthors if needed. The data extracted consisted of the study population (country, age, sex, education, any specific variables); study methodology (study design, sample recruitment method, data collection method, and response rate); the type of social network they exposed, outcome measures, confounders, and analytical methods). If data clarification and missing information was needed, we contacted the corresponding author or coauthors for a maximum of three times through email.(Lo, Mertz, & Loeb, 2014) When multiple reports of the same study were found, we checked if these articles reported the same result. In this analysis, three articles from the same study 'AppHealth' reported different results.

Newcastle Ottawa Scale

The Newcastle Ottawa Scale (NOS) (G. Wells et al., 2000) was adopted to develop a tool for the assessment of the internal and external validity of the included studies. Each of the studies was rated according to the NOS tool giving a number of asterisks out of 10. If the paper met the NOS tool

requirement criteria, one or two asterisks were rewarded for each of the criteria, in total 10. The evaluation of each study and the scores are presented in Table 3.2. The first author assigned the rating and checked with the co-authors in the case of uncertainty.

Analyses

The studies were grouped according to the outcome categories; ever having sex or having an early sexual debut. All studies reported odds ratios (OR) either adjusted or unadjusted to find the association between exposures and results. We used the adjusted OR if the author provided both. The beta coefficients were also converted to OR. If the author did not provide a 95% confidence interval, we calculated it based on the standard error and sample size of the study. There were three studies that provided the mean value without the standard error Nwagwu (2017) Nwagwu (2017), Mladenovik (2010),(Mladenovik et al., 2010) and Handebo (2018) (Handebo et al., 2018).

We calculate the combined OR by meta-analysis for exposures, which two or more studies estimated. In the meta-analysis, we used random effects models because heterogeneity was high above 50% in some exposures. The heterogeneity value I^2 was described for each of the subgroup analyzes in the meta-analysis. The funnel plot was drawn to assess the publication bias in the meta- analysis. (Sterne & Harbord, 2004) Stata version 13 was used for the analysis.

Results

Literature search

There were 19,577 articles identified from the literature search; after removing 3,127 duplicate records, 16,450 articles were eligible for the title and abstract review. After reviewing the titles and abstracts, we further reviewed 89 articles for full-text articles, and 23 articles were finally selected for narrative synthesis (Table 4.2).

Among these 23 studies, three publications reported different outcomes from the same study population.(Majumdar, 2006; Rink, Tricker, & Harvey, 2007; Roche et al., 2005) Sixteen articles reported data relating to ever having sex (C. R. Browning, Soller, & Jackson; Bukenya et al., 2020b; E. Fearon et al., 2019; Foster et al., 2017; Harrison et al., 2012; Jonsson et al., 2015; Kreager & Staff, 2009; Landry et al., 2013; Le Linh & Blum, 2009; D. Y. Lee et al., 2012; Nwagwu, 2017; Rink et al., 2007; Roche et al., 2005; Vandenbosch et al., 2016; Wiegerink, Roebroeck, Van Der Slot, Stam, & Cohen-Kettenis, 2010; M.-L. Wong et al., 2009) and seven papers reported data related to early sexual debut. (Handebo et al., 2018; Kuzman et al., 2007; Majumdar, 2006; Mladenovik et al., 2010; Stephenson, Simon, & Finneran, 2014) (Alhassan, Abdulai, & Alhassan, 2021) (Van Ouytsel, Lu, & Temple, 2021)

Nineteen studies were cross-sectional studies (C. R. Browning et al.; Bukenya et al., 2020b; E. Fearon et al., 2019; Foster et al., 2017; Handebo et al., 2018; Harrison et al., 2012; Jonsson et al., 2015; Kuzman et al., 2007; Landry et al., 2013; Le Linh & Blum, 2009; D. Y. Lee et al., 2012; Majumdar, 2006; Mladenovik et al., 2010; Nwagwu, 2017; Stephenson et al., 2014; Wiegerink et al., 2010) (Van Ouytsel et al., 2021) (Alhassan et al., 2021) , three were cohort (Kreager & Staff, 2009; Rink et al., 2007; Roche et al., 2005; Vandenbosch et al., 2016) and one was a case control study (M.-L. Wong et al., 2009).

All studies apart from three (E. Fearon et al., 2019; Rink et al., 2007) (Alhassan et al., 2021) included male and female participants. The age of the participants ranged from 10 to 24 years old.

Thirteen studies involved secondary school students with an age range of 12-20 years (E. Fearon et al., 2019; Foster et al., 2017; Handebo et al., 2018; Harrison et al., 2012; Kreager & Staff, 2009; Kuzman et al., 2007; Landry et al., 2013; D. Y. Lee et al., 2012; Majumdar, 2006; Mladenovik et al., 2010; Rink et al., 2007; Roche et al., 2005; Vandenbosch et al., 2016), one study reported on secondary students with an age range of 16-22 years(Jonsson et al., 2015), one study recruited 7th grade student with mean age of 12.68 years (Van Ouytsel et al., 2021), one study involved university students with mean age of 19.5 (Nwagwu, 2017); seven studies combined students and nonstudents with an age range of 12-24 years (C. R. Browning et al.; Bukenya et al., 2020b; Le Linh & Blum, 2009; Stephenson et al., 2014; Wiegerink et al., 2010; M.-L. Wong et al., 2009) (Alhassan et al., 2021)

These reports were of studies conducted in various countries; eight in the USA (C. R. Browning et al.; Foster et al., 2017; Kreager & Staff, 2009; Landry et al., 2013; Majumdar, 2006; Rink et al., 2007; Roche et al., 2005), three in South Africa (E. Fearon et al., 2019; Harrison et al., 2012; Jonsson et al., 2015), one in Belgium (Vandenbosch et al., 2016), one in Netherlands (Wiegerink et al., 2010), one in Macedonia (Mladenovik et al., 2010), one in Croatia,(Kuzman et al., 2007) one in Nigeria(Nwagwu, 2017), one in Ethiopia (Handebo et al., 2018), two in Ghana (Stephenson et al., 2014), one in Uganda (Bukenya et al., 2020b), one in Singapore(M.-L. Wong et al., 2009), one in Korea (D. Y. Lee et al., 2012) and one in Vietnam (Le Linh & Blum, 2009).

Studies were published between 2005 and 2021. The number of participants ranged from 87 to 65,672 and the median was 1,081. Participants were recruited from high schools in 13 studies (Handebo et al., 2018; Jonsson et al., 2015; Kreager & Staff, 2009; Kuzman et al., 2007; Landry et al., 2013; D. Y. Lee et al., 2012; Majumdar, 2006; Mladenovik et al., 2010; Nwagwu, 2017; Rink et al., 2007; Roche et al., 2005; Vandenbosch et al., 2016) (Van Ouytsel et al., 2021) ,a university in 1 study(Nwagwu, 2017), households in - 5 studies(C. R. Browning et al.; Bukenya et al., 2020b; Le Linh & Blum, 2009; Stephenson et al., 2014), (Alhassan et al., 2021), a community venue in 1 study(E. Fearon et al., 2019), a rehabilitation centre for cerebral palsy in 1 study(Wiegerink et al., 2010), a sexually transmitted disease and primary care clinic in 1 study(M.-L. Wong et al., 2009), and a paediatric emergency clinic in 1 study (Foster et al., 2017).

Table 4-1 Overview of the included studies (n= 23)

Studies with the outcome "Ever having sex" (n= 16)

Author	Year	Sample size	Study population	Study details	Exposures	Statistical method
Fearon, E., et al. (2019)	2019	2,326	Rural Mpumalanga, northeast South Africa, 8-11 grade 8-11, girls, age 13-20 years	Cross-sectional study using baseline data from the HPTN068 Conditional Cash Transfer (CCT) trial, March 2011 to December 2012, households were identified as having potentially eligible participants from the annual census round. An audio-computer-assisted self-interview was used. 2537 participants at	Friendship density, which is defined as the number of reported friend-to-friend ties divided by the total number of possible friend-to-friend ties.	Linear regression model (age, grade, SEP, orphanhood, mother and father's education, and friendship network sociodemographic variables were adjusted).

Author	Year	Sample size	Study population	Study details	Exposures	Statistical method
				baseline and 2326 participants (91.5%) in the analysis. Sampling Method: NA, validation of tool NA.		
Nwagwu, W. E. (2017)	2017	388	Public universities in Nigeria, Male and female, university students, mean age 19.5 years	Cross-sectional study, June-August 2013, Stratified sampling method, structured questionnaire-guided data collection, response rate-NA and validation of the tool was carried out.	Increased social networking behaviour.	Hierarchical binary logistic regression (age, sex, social identity, personal identity, collective identity, social networking, intimate relationship, no sexual partners, condom used during the last sex, attitude towards condoms were controlled).
Lee et al. (2012).	2012	75,238	Korea, school students and age 12 to 18 years	Cross-sectional nationwide study in 2008, Korean Youth Risk Behaviour web-based survey, stratified multistage random cluster sampling, response rate 95.1%, validation of the tool- not applicable	Internet use at weekends is controlled.	Multivariate regression, survival analysis (type of school, formal sex education, school record, experience of drinking, smoking, drug use, living with parents and economic status) were controlled).
Foster, C. E., et al. (2017)	2017	224	US metropolitan areas, 7th to 9th grade school children, 12 to 15 years old.	Cross-sectional, January 2010- September 2014, as part of the Let's Connect community-based mentorship program survey, everyone who attended paediatric emergency department or co-located urgent care clinic was approached for the survey, 45-60 minute evaluation at the emergency department/medical clinic by research assistance. Tool validation not available.	Connectedness to school, community, or peers.	Linear and logistic regression (age, sex, victimization, perpetration) were controlled).
Browning, C. R., et al. (2015)	2015	830	Logs Angeles County, USA, 12 to 17 years old, male and female	Cross-sectional study (Wave 1 of the LA FANS cohort study 2000-2001), stratified random sample of 65 census tracts, within a household, a randomly selected child and one of the child's siblings were interviewed, tool validation NA.	Reinforcement in eco-networks: tendencies for neighbourhood residents to engage in shared activities within two or more routine activity clusters.	Three-level Rash models. (concentrated disadvantage, immigrant concentration, residential instability, percentage of African American, number of locations, informal social ties, social disorder, collective efficacy, and intergenerational closure were controlled).

Author	Year	Sample size	Study population	Study details	Exposures	Statistical method
Harrison, A., et al. (2012)	2012	983	Umkhanyakude District, South Africa, Grade 8, 9 and 10 students, Male and female, age 14 to 17 years old	Cross-sectional study, March 2003, interviewers administered the survey. Recruitment method- NA, tool validation- NA.	Perception that their peers are sexually active	The T test and generalised estimating equations (age, gender role norms and values, and risk perception were controlled).
Jonsson, L. S., et al. (2015)	2015	3,504	Sweden, Male and female, Grade 8-9 students, 16 to 22 years old, response rate 60.5%	Cross-sectional study, Jan-April 2009, sample was selected using Swedish school register, random sample was collected. The questionnaires were completely anonymous in the class. Tools adopted from the Baltic Sea Regional Study of Adolescent Sexuality.	Met someone online and had sex offline.	Multiple logistic regression (living with both parents, academic/vocational study program, father's occupation, mother's occupational status, father's education, mother's education, adolescents region of birth,, parental region of birth and parental bonding instruments were adjusted).
Rink, E., et al. (2007)	2007	3,644	US, only female, school girls, 15 to 19 years old	Cohort study (Add health study), Wave 1- 1995, Wave 2 (1996), Wave 3 (2002), multistage clustering design, in-home interview, tool validation- NA.	Connectedness to father, mother and peer (five-point Likert scale from 1= strongly agree to 5= strongly disagree).	Logistic regression method (Age, race, depression, self-esteem, religiosity, alcohol use, and perception of sex are controlled).
Roche, K. M., et al. (2005)	2005	2,559	US, African and Latino adolescents, male and female, seventh- and 8th grade students, 12 to 16 years	Cohort study (Add health study) (National longitudinal study 1995), stratified random sampling, in-home interview, tool validation NA.	Affiliation with deviant peers.	Multiple logistic regression (decision making, inside activities, parental participation, parental communication about sex, stepparent family, gender, race, household income and pubertal development) was controlled.
Vandenbosch, L., et al. (2016)	2016	1,163	Flanders, Belgium, Male and female, school children, 12 to 18 years	Cohort study, two waves panel data, 2010, paper survey at school during school hours, recruitment method- NA, tool validation- NA, response rate 77.3%.	Use of chat rooms and dating websites (never= 1, all day = 8) Use of erotic contact websites (never=1, several times a day=7).	Logistic regression (age, communication with parents, communications with peers, and gender were controlled).
Wiegerink, D. J., et al. (2010)	2010	87	Netherlands, Dutch adolescents with cerebral palsy, male and female, age 18 to 22 years, response rate 56%	Cross-sectional, (a part of the longitudinal cohort study), participants were recruited from eight rehabilitation centres and departments in the southwestern regions of the Netherlands. Recruitment method: NA, tool adopted from the Vineland Adaptive	Peer group activity.	Bivariate and multivariate analysis (age, education, preceding stage (dating, romantic relationship and number of friends sex of the friends were controlled)

Author	Year	Sample size	Study population	Study details	Exposures	Statistical method
				Behaviour Scales, response rate 85%.		
Wong, M.-L., et al. (2009)	2009	1,000	Singapore, male and female, 14 to 19 years old	Case-control study, 2006 to 2008, cases- those attending the only public department of SIT control clinic, control - nonsexually active adolescents attending a primary care clinic, face-to-face interview, recruitment method- NA, tool validation- NA	Perceived that one-half or more of friends already had sex, Not confident in resisting peer pressure to engage in sex.	Logistic regression model (lived in low-cost housing, alcohol use, smoker, involved in gang activities, thought that one can have sex before marriage, perceived that one half or more of friends already had sex, not confident in resisting peer pressure to engage in sex, and read or watched were controlled).
Kreager, D. A. (2016)	2016	914	US, rural communities in Iowa and Pennsylvania, 6th to 9th grade students, 11 to 16 years old.	Longitudinal study, Prosper longitudinal study, 2004, random sample, pencil and paper questionnaires interview tool validation- NA.	Peer acceptance- the number of incoming friendship ties received.	Xt regression (family attachment, grades, religious attendance, delinquency, drinking, and changed school were controlled).
Le Linh, C. and R. W. Blum (2009)	2009	2,210	Vietnam, male and female, 15 to 24 years, college, vocational, secondary, primary, no school.	Cross-sectional study, randomised sample to households, face-to-face interview, pencil and paper, and audio-computer-assisted interview, tool validation- NA.	Connectedness with mother, school, peers.	Multiple regression ((age, education, live with biological parents, family history of mental illness, family members are arrested, mother drug use, father drug use and parental control were controlled).
Landry, M., et al. (2013)	2013	428	US Maryland, Latino, ninth and 10th grade students, 13 to 20 years.	Cross-sectional study, fall 2011 or spring 2012, recruitment method- NA, tools were drawn from standardised and validated instruments used in previous surveys of Latino adolescents, including the Youth Risk Behaviour Survey (YRBS).	Number of SMS per day, number of log-in to the social network.	Multivariate regression (sex, US born or not,, age, Spanish or not and number of social media accounts were controlled).
Bukenya et al., (2020)	2020	600	Uganda, Male and female, 10-19 years,	Cross-sectional study, recruitment method randomly selected, tools were adopted from the validated instruments used in previous survey of Global School-based Health Survey	Sexting	The multivariate model (age, sex, and school status were adjusted).

Studies with the outcome “Early sexual debut” (n= 17)

	Year	Sample size	Study population	Study details	Exposures	Statistical method
Handebo, S., et al. (2018)	2018	628	North Shewa Zone, Ethiopia, Grade 9, 10 school students, mean age 17.57 years.	Cross-sectional study, February to March 2016, multistage sampling method, self-administered questionnaires. Tool validation-NA. early sexual debut before 18 years old.	Connectivity with family and school measured by the seven items on the Likert scale items.	Backward likelihood logistic regression (age, sex, household income, grade level, living arrangement, substance use, and beliefs towards safe sexual activities were controlled).
Stephenson et al. (2014).	2014	1,787	Burkina Faso, Ghana, Malawi and Uganda, male and female, aged 12-19 years.	Cross-sectional study, 2004 National survey of adolescents, two-stage stratified sampling design, interview, overall response rates ranged from 87% in Uganda to 95% in Burkina Faso, tool validation-NA, early sexual debut, before the median age of the first sex of the whole sample.	Number of the close friends of same sex, number of close friends of different sex.	A logistic regression model. (education, work, ethnicity, religion, live with parents, medical exposure, belong to social group, RH knowledge index, participated in puberty rite, person outside of the family, number of close male friends, number of close female friends, ever drink alcohol, and community control).
Kuzman, M., et al. (2007)	2007	1,630	Croatia, fourth and seventh grades in primary school and first grades in secondary school, male and female, mean age 15.5 years.	Cross-sectional study, national school-based survey in 2006, Sampling unit was a class, the list of classes at national level was randomly selected, structure questionnaires were completed anonymously in the regularly scheduled classroom period. Tool validation-NA, early sexual debut-16 or less.	Having three or more close friends of opposite sex.	Binary logistic regression of other risk behaviour [smoking, drinking alcohol, Marijuana use, physical fight, being bullied in the last couple of months, bullying others in the last couple of months, health (satisfied with one's own health, satisfied with life, psychosomatic symptoms) and family (easy talk with father, easy talk to mother) were controlled.
Mladenovik, B., et al. (2010)	2010	1,226	Macedonia, secondary students, male and female, 15-17 years old.	Cross-sectional study, February to April 2009, respondents were randomly selected, questionnaires were anonymous, and nonresponse rate was low. Tools were adapted questionnaire prepared for the WHO "Health Behaviour in School Children.	Number of evening spending with friends (more than 4 days/ less than 4 days).	Chi-square, Mann-Whitney U and Student T test

	Year	Sample size	Study population	Study details	Exposures	Statistical method
				Early sexual debut-less than 16.		
Majumdar (2006)	2006	7,508	US male and female, mean age 17 years, seventh and 12th grade school students.	Cross-sectional study, wave 1 of the national school-based national longitudinal study of adolescent Health (Add health project), 1997, cluster sampling, 90-minute in-home interview, tool validation-NA. Early sexual debut-less than 14.	Interaction with the best friend.	Multiple logistic regression (age, income, religiosity, sex, substance use by friend, family structure, race, and romantic relationship were adjusted).
Van Ouytsel (2021)	2021	2,768	US, young adolescents, male and female, mean age = 12.68 years	Baseline data from randomized controlled trial of a school-based dating violence prevention program. 2021, Sampling method – NA., paper and pencil survey for 45 minutes, tool validation-NA. Early sexual debut-less than 13	Pressured into sexting	Chi-square test, Fisher's exact tests
Alhassan (2021)	2021		Ghana, adolescent females, 15-24 years old.	Ghana Multiple Indicator Cluster Survey 2017-2018 Sampling method-Household census Tool validation- NA Early sexual debut-14	Socio demographic information	Logistic regression model

Assessment of study quality

The NOS scale scores ranged from 6 to 9 with a median of 8 (or asterisks). The area where studies were awarded less asterisks was the calculation of the sample size calculation. Most studies did not explain the method of sample size calculation. The second area that lost an asterisk was the absence of controlling for confounding factors in the analysis; two studies did not control for confounding factors(Foster et al., 2017; Mladenovik et al., 2010). Table 4.2 shows the list of asterisks for each study. Of the 15 studies of "Ever having sex', four used stratified random sampling (C. R. Browning et al.; Nwagwu, 2017; Rink et al., 2007; Roche et al., 2005) , four used random sampling (Bukenya et al., 2020b; Jonsson et al., 2015; Kreager & Staff, 2009; Le Linh & Blum, 2009), four convenient sampling (E. Fearon et al., 2019; Foster et al., 2017; Wiegerink et al., 2010; M.-L. Wong et al., 2009), and three nonspecified (Harrison, Vanden, Landry) (Harrison et al., 2012; Landry et al., 2013; Vandenbosch et al., 2016). Of the eight studies of 'Early sexual debut", two studies used stratified sampling (Handebo et al., 2018; Stephenson et al., 2014), two random sampling (Kuzman et al., 2007; Mladenovik et al., 2010) and one cluster sampling (Majumdar, 2006) one randomized control sampling (Van Ouytsel et al., 2021), and one household sampling (Alhassan et al., 2021).

The results and exposures of the study were determined using self-reporting. Apart from eight studies (Foster et al., 2017; Jonsson et al., 2015; Landry et al., 2013; Mladenovik et al., 2010; Nwagwu, 2017; Wiegerink et al., 2010), (Turi, Merga, Fekadu, & Abajobir, 2020) (Alhassan et al., 2021). Other studies did not report validation of the measurement tools.

Table 4-2 Assessment of studies based on adapted Newcastle Ottawa Scale for cross sectional studies

Study	Selection (maximum 5 asterisks)				Study adjustments (maximum 2 asterisks)	Outcome (maximum 3 asterisks)		Overall (maximum 10 asterisks)
	1. Representative sample	2. Sample size	3. Non-respondents	4. Ascertainment of the exposure	5. Confounding factors are controlled	6. Assessment of the outcome	7. Statistical test	Total asterisks
Fearon, E., et al. (2019)	*	*	*	*	*	*	*	7
Stephenson, R., et al. (2014).	*	*	*	**	**	*	*	9
Nwagwu, W. E. (2017)	*	-	-	**	*	*	*	6
Lee, D. Y., et al. (2012).	*	*	*	-	**	*	*	7
Kuzman, M., et al. (2007)	*	*	*	**	*	*	*	8
Mladenovik, B., et al. (2010)	*	*	*	**	-	*	*	7

Study	Selection (maximum 5 asterisks)				Study adjustments (maximum 2 asterisks)	Outcome (maximum 3 asterisks)		Overall (maximum 10 asterisks)
Foster, C. E., et al. (2017)	*	-	*	**	-	*	*	6
Browning, C. R., et al. (2015)	*	*	*	**	**	*	*	9
Handebo, S., et al. (2018)	*	*	*	**	**	*	*	8
Harrison, A., et al. (2012)	*	*	*	*	**	*	*	8
Jonsson, L. S., et al. (2015)	*	*	*	**	**	*	*	9
Rink, E., et al. (2007)	*	*	*	*	**	*	*	8
Vandenbosch, L., et al. (2016)	*	*	*	*	**	*	*	8
Wiegerink, D. J., et al. (2010)	*	*	*	**	**	*	*	9
Majumdar (2006)	*	-	*	*	**	*	*	7
Le Linh, C. and R. W. Blum (2009)	*	-	*	*	**	*	*	7
Landry, M., et al. (2013)	*	*	*	**	**	*	*	9
Bukenya et al., (2020)	*	*	*	**	**	*	*	9
Van Ouytsel (2021)	*	*	*	*	*	*	*	7
Alhassan (2021)	*	*	*	**	**	*	*	9

Table 4-3 Assessment of studies based on adapted Newcastle Ottawa Scale for the cohort studies

Study	Selection (maximum 4 asterisks)				Study adjustments (maximum 2 asterisks)	Outcome (maximum 4 asterisks)				Overall (maximum 10 asterisks)
	1. Representative sample	2. Non-respondents	3. Ascertainment of the exposure	4. Outcome – not set at the beginning	5. Confounding factors are controlled	6. Assessment of the outcome	7. Follow-up period	8. Retention rate	9. Statistical test	Total asterisks
Roche, K. M., et al. (2005)	*	*	*	*	*	-	*	*	*	8
Kreager, D. A. (2016)	*	*	*	*	*	-	*	*	*	8

Table 4-4 Assessment of studies based on adapted Newcastle Ottawa Scale for the case control studies

Study	Selection (maximum 4 asterisks)				Study adjustments (maximum 2 asterisks)	Exposure (maximum 4 asterisks)				Overall (maximum 10 asterisks)
	1. Case definition	2. Representativeness of cases	3. Section of control	4. Control definition	5. Confounding factors are controlled	6. Ascertainment of exposure	7. Method of ascertainment	8. Non-response	9. Statistical test	Total asterisks
Wong, M.-L., et al. (2009)	*	*	-	*	*	*	*	*	*	8

Ever having sex

Among 16 studies that explored the exposure of "ever having sex", all apart from two studies (E. Fearon et al., 2019; Rink et al., 2007) included male and female participants. The age of the participants ranged from 10 to 24 years. Nine studies involved secondary school students with an age range of 12-20 years(E. Fearon et al., 2019; Foster et al., 2017; Harrison et al., 2012; Kreager & Staff, 2009; Landry et al., 2013; D. Y. Lee et al., 2012; Rink et al., 2007; Roche et al., 2005; Vandenbosch et al., 2016), one study concerned secondary students with an age range of 16-22 years(Jonsson et al., 2015), one sampled university students with a mean age of 19.5 (Nwagwu, 2017); and five studies included students and nonstudents with an age range of 12-24 years (C. R. Browning et al.; Bukenya et al., 2020b; Le Linh & Blum, 2009; Wiegerink et al., 2010; M.-L. Wong et al., 2009).

These reports were of studies conducted in various countries; six studies from the US (C. R. Browning et al.; Foster et al., 2017; Kreager & Staff, 2009; Landry et al., 2013; Rink et al., 2007; Roche et al.,

2005), three studies from South Africa (E. Fearon et al., 2019; Harrison et al., 2012; Jonsson et al., 2015), and one study for each Nigeria(Nwagwu, 2017), Uganda(Bukenya et al., 2020b) , Belgium(Vandenbosch et al., 2016), Netherlands(Wiegerink et al., 2010), Korea(D. Y. Lee et al., 2012), Singapore(M.-L. Wong et al., 2009) and Vietnam(Le Linh & Blum, 2009). The number of participants ranged from 87 to 65,672 and the median was 1000. Participants were recruited from high schools in eight studies, a university in one study(Nwagwu, 2017), households in two studies (C. R. Browning et al.; Le Linh & Blum, 2009), a community venue in one study(E. Fearon et al., 2019), a rehabilitation center for cerebral palsy in one study(Wiegerink et al., 2010), a sexually transmitted disease and primary care clinic in one study(M.-L. Wong et al., 2009), and a pediatric emergency clinic in one study (Foster et al., 2017).

Exposure ascertainment

There were six main exposures: Network density, connectedness, perception of sexual activity, use of the internet for dating or other purposes, having deviant peers and peer interaction.

Network density was measured by Fearon as the percentage of friends-to-friends ties out of the possible friend ties (E. Fearon et al., 2019), and Browning measured it by the tendencies of neighborhood residents to engage in shared activities (C. R. Browning et al.).

With regard to connectedness, the authors measured connectedness to mother, father, peers, schools, or community. Le measured by Le as the total score of four items whether the participants felt that mother cared, showed love, discussed problems and was close to the respondent(Le Linh & Blum, 2009), Rink used a five-point Likert scale to measure mother's warmth toward the respondent, encouraged for independence, discussed ethics, had good communication and had a good relationship (Rink et al., 2007). Connectedness to peers reported by Foster used a scale which assessed trust and perceived support among peers (Foster et al., 2017), while Rink employed a five-point Likert scale to measure perceptions on how friends take care of the respondent (Rink et al., 2007). For school connectedness, Foster scored whether the respondents felt being part of the school and whether teachers took care of them(Foster et al., 2017); Rink measured whether the respondent felt close to the people at school, felt being a part of the school community, felt safe at school, felt happy at school, whether students were seen as prejudiced, and whether teachers treated students fairly (Rink et al., 2007). For connectedness to the community, Foster used a four-point Likert scale for three items of community connectedness, namely: the desire to reside in the community when they got older, the value placed on relationships with adults in the neighbourhood, and if there were adults in the neighbourhood the respondent could go to if they needed help (Foster et al., 2017). For the connectedness to father, Rink asked respondents if their father was warm to the respondent and if there was good communication and a good relationship between the father and respondent (Rink et al., 2007).

The perception that peers were sexually active referred to the perception that half or more of their friends already had sex (Harrison et al., 2012; M.-L. Wong et al., 2009); or at least one friend who was perceived to have sex (E. Fearon et al., 2019). Josson and Vandenbosch evaluated the use of the internet for dating. Josson asked if the respondent had sex with someone on the internet during the last 12 months(Jonsson et al., 2015); and Vandenbosch asked if the respondent used chat rooms and dating websites. (Vandenbosch et al., 2016) Having deviant peers was measured by Le Linch and Roche. Le Linch defined the deviance of peers by using the social deviance scale (Le Linh & Blum, 2009), while Roche measured the peer deviance by describing the affiliation with deviant peers compared to other youths(Roche et al., 2005).

A range of questions about Internet use included the use of social network sites (Nwagwu, 2017), the use during weekends (D. Y. Lee et al., 2012), higher use of SMS and frequently logging into social network sites (Landry et al., 2013), the frequent use of erotic websites frequently (Vandenbosch et al., 2016) and sexting(Bukenya et al., 2020b). Peer interactions were examined in some studies. Wiegerink asked participants if they participated in the peer group activities regularly(Wiegerink et al., 2010); Wong asked questions about participants' confidence in resisting peer pressure to engage in sex(M.-L. Wong et al., 2009); and Kreager assessed peer acceptance with questions about the number of incoming friendship requests the respondent received (Kreager & Staff, 2009).

Outcome ascertainment

Ever having sex was examined by 16 studies; and early sexual debut by 5 studies. Six studies asked if the respondents ever had sex; five studies asked if the respondent had sexual intercourse in their lifetime(Foster et al., 2017) or sexual debut(D. Y. Lee et al., 2012) or had sexual initiation(Roche et al., 2005; Vandenbosch et al., 2016) or engaged in fisting during sex(Kreager & Staff, 2009); and the remaining four studies asked if the respondent had premarital sex (Le Linh & Blum, 2009) or had sexual experience(Wiegerink et al., 2010) or had sex.(M.-L. Wong et al., 2009).

The age of the first sexual experience of the participants ranged between 14-17 years in Harrison (less than 13 years old was considered an early sexual debut) (Harrison et al., 2012), 12-16 years in Roche (age of first sex- Non Applicable (NA)) (Roche et al., 2005), 12-15 years in Foster (age of first sex- NA) (Foster et al., 2017), 12-17 years in Browning(C. R. Browning et al.), 12-18 in Vandenbosch (age of first sex- NA) (Vandenbosch et al., 2016), 11-16 in Kreager (age of first sex- NA) (Kreager & Staff, 2009), 12-18 in Lee (age of first sex- NA) (D. Y. Lee et al., 2012), and 12-15 in Foster (age of first sex- NA) (Foster et al., 2017). In some studies, the range of age of first sexual experience went beyond 18; 13-20 in Fearon (age of first sex- NA) (E. Fearon et al., 2019), 16-22 in Jonsson (age of first sex- NA) (Jonsson et al., 2015), 15-19 in Rink (age of first sex- NA) (Rink et al., 2007), 18-22 in Wiegerink (age of first sex- NA) (Wiegerink et al., 2010), 14-19 in Wong (age of first sex- 16) (M.-L. Wong et al., 2009), 15-24 in Le Linh (age of first sex- 21)(Le Linh & Blum, 2009), 13-20 in Landry (age of first sex- NA)(Landry et al., 2013) and 19.5 in Nwagwa (age of first sex- NA)(Nwagwu, 2017).

Meta-analysis

Meta-analysis was performed for five exposures; connectedness to mother; connectedness to peers; connectedness to school; perception that peers were sexually active; and the use of the internet for dating using random effect model (Figure 3-3)

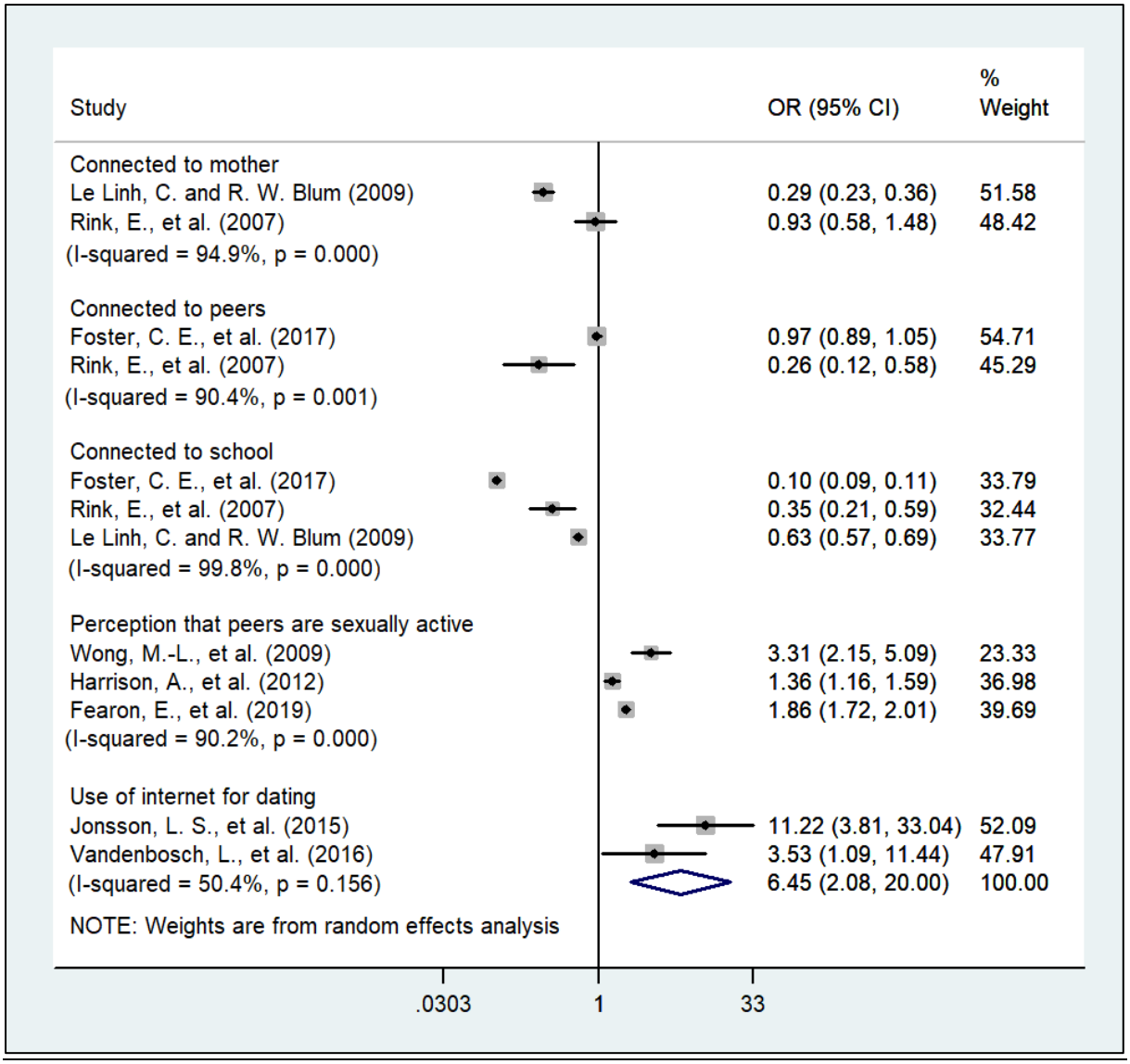


Figure 4-2 Meta-analysis and forest plot of studies describing association between various exposures and outcome "having ever sex"

An association was observed in two studies reporting on the relationship between use of internet for dating and having ever sex (pool OR 6.45, 95% confidence interval (CI); 2.08 – 20.00). Because of the significant heterogeneity, a pooled OR was not calculated for connectedness to mother; connectedness to peers; connectedness to school and perception that peers were sexually active.

Single study correlations

The different exposures reported in one study are listed in Table 3. A correlation was observed between a lower chance of ever having sex and greater enforcement of networks (OR 0.92, 95% CI 0.86 – 0.99)(C. R. Browning et al.); having father connection (OR 0.50, 95% CI 0.35 – 0.75) (Rink et al., 2007), having parents involved in their decision making (OR 0.5, 95% CI: 0.53- 0.65)(Roche et al., 2005) and having peer acceptance in female participants (OR 0.60, 95% CI 0.58 – 0.68)(Kreager & Staff, 2009). The higher chance of ever having sex was associated with being less confident in resisting peer pressure to engage in sex (OR 3.84, 95% CI: 2.27 – 6.50) in male participants and (OR 5.56, 95% CI 2.94-10.53)(M.-L. Wong et al., 2009) in female participants; having peer acceptance in male participants (OR 2.02, 95% CI 2- 2.11)(Kreager & Staff, 2009); going out in youth with peer group activities in

cerebral palsy youths (OR 4.56, 95% CI 1.57- 13.24)(Wiegerink et al., 2010), having peers who were socially deviant (OR 3.74, 95% CI 3.67, 3.81)(Le Linh & Blum, 2009) and having greater affiliation with deviant peers (OR 1.46 (95% CI 1.42, 1.50) (Roche et al., 2005).

Table 4-5 Studies describing association between various exposures and ever having sex or not

Exposure type	Exposure	OR 95% CI (as reported in the paper unless otherwise stated)	Sex	Authour
Network density	Lower network density (number of friend-to-friend ties)	0.96 (0.93 - 1)[A]	Female	Fearon, E., et al. (2019)
	Higher eco-network enforcement	0.92 (0.86- 0.99)[B,C]	Both	Browning, C. R., et al. (2015)
Connectedness	Community connectedness	1.28 (1.06 - 1.54) [A]	Both	Foster, C. E., et al. (2017)
	Father connectedness	0.50 (0.35- 0.75)[A]	F	Rink, E., et al. (2007)
	Parents' involvement in the decision making	0.50 (0.53, 0.65)[B]	Both	Roche, K. M., et al. (2005)
Internet use	Use of social networking site	0.194 [C]	Both	Nwagwu, W. E. (2017)
	Internet use at weekends	0.55 (0.47 - 0.63)[A]	M	Lee, D. Y., et al. (2012).
	Internet use at weekends	0.76 (0.61 - 0.94)[A]	F	Lee et al. (2012).
	High SMS use, > 100 SMS per day	2.01 (1.02 - 3.99)	Both	Landry, M., et al. (2013)
	Log to in social network at least once per day	2.10 (1.08 - 4.11)[A]	Both	Landry, M., et al. (2013)
	Erotic contact website frequent users/ non-users (ref)	5.59 (2.30 - 13.61)[A]	Both	Vandenbosch, L., et al. (2016)
	Sexting	1.54 (1.14, 2.08) [A]	Both	Bukenya et al., (2020)

Exposure type	Exposure	OR 95% CI (as reported in the paper unless otherwise stated)	Sex	Authour
Peer interaction	Going out in the peer group activities regularly	4.56 (1.57 - 13.24)[A]	Both	Wiegerink, D. J., et al. (2010)
	Not confident in resisting peer pressure to engage in sex	3.84 (2.27 - 6.50)[A]	Male	Wong, M.-L., et al. (2009)
	Not confident in resisting peer pressure to engage in sex	5.56 (2.94 - 10.53)[A]	Female	Wong, M.-L., et al. (2009)
	Peer acceptance- the number of incoming friendship ties received (i.e., network indegree) from same-grade peers, in female participants	0.60 (0.58 - 0.68) [B,C]	Female	Kreager, D. A. (2016)
	Peer acceptance, the number of incoming friendship ties received (i.e., network degree) from same-grade peers, in male participants	2.02 (2- 2.11) [B,C]	Male	Kreager, D. A. (2016)
	Number of evening spending with friends (more than 4 days/ less than 4 days)	3.29[E]	Both	Mladenovik, B., et al. (2010)
	Number of days spent with friends (more than 4 days/ less than 4 days)	1.79[E]	Both	Mladenovik, B., et al. (2010)
	Having interaction with best friends (gender- non-specific)	0.95 (0.94, 0.97)[B]	Both	Majumdar (2006)
	Peer social deviance	3.74 (3.67, 3.81)[B]	Both	Le Linh, C. and R. W. Blum (2009)
	Greater affiliation with deviant peers among youth who initiated sex	1.46 (1.42, 1.50)[A]	Both	Roche, K. M., et al. (2005)

A- Adjusted OR,
B- Adjusted OR (95% CI), but 95% is calculated by the reviewer.
C- Derived from beta value by reviewer, unable to calculate 95% CI
D- correlation coefficient
E- Derived from the numbers by the reviewer

Early sexual debut

Among the five studies, all included male and female participants (Handebo et al., 2018; Kuzman et al., 2007; Majumdar, 2006; Mladenovik et al., 2010; Stephenson et al., 2014). The age of the participants ranged from 10 to 24 years old. Four studies(Handebo et al., 2018; Kuzman et al., 2007; Majumdar, 2006; Mladenovik et al., 2010) involved secondary school students with an age ranging from 15 to 17.5 years while in one study(Stephenson et al., 2014) the age ranged from 12 to 19 years, with the school status not identified. These reports were of studies conducted in various countries; Ethiopia(Handebo et al., 2018), Ghana(Stephenson et al., 2014), Croatia(Kuzman et al., 2007), Macedonia(Mladenovik et al., 2010) and US(Majumdar, 2006). The number of participants ranged from 628 to 7,508 and the median sample was 1,226. Participants were recruited from high schools in four studies (Handebo et al., 2018; Kuzman et al., 2007; Majumdar, 2006; Mladenovik et al., 2010) and from households in one study(Stephenson et al., 2014).

Exposure ascertainment

There were three main exposures: having more close friends of the same sex or opposite sex, the number of days or evenings spent with friends, and interacting with peers, sexting, and use of the internet. For having close friends; Stephson measured the number of close friends of same sex in male and female respondents separately(Stephenson et al., 2014); while Kuzman measured the number of close friends of opposite sex in male and female respondents separately(Kuzman et al., 2007). Maldenovik asked the number of evenings or days the respondent spent with friends(Mladenovik et al., 2010); and Majumdar asked the frequency of interactions with best friends (Majumdar, 2006).

Outcome ascertainment

Five studies explored early sexual debut with similar questions; Hadnebo asked about experience with sex before the age of 18 years (Handebo et al., 2018); Stephenson asked about sex encounters before the median age of first sex of the whole sample(Stephenson et al., 2014); Kuzman asked about sex at age 16 or earlier(Kuzman et al., 2007); Mladenovik asked about sex at age earlier than 16(Mladenovik et al., 2010); and Majumdar and Alhassan asked about sex before the age of 14 (Majumdar, 2006; Mladenovik et al., 2010) (Alhassan et al., 2021) and Van asked about sex before age of 13 (Van Ouytsel et al., 2021).

Meta-analysis

Meta-analysis was not performed for the outcome ‘Early sexual debut” because there were less than two studies for each exposure.

Single study correlations

The different exposures that were reported in one study are listed in Table 4. A correlation was observed between the lower chance of having early sexual debut and having more close friends of the same sex in female participants (OR 0.83, 95% CI 0.71-0.96) (Stephenson et al., 2014); having interaction with best friends (gender not specified in participants or peers). (Majumdar, 2006) A higher chance of having early sexual debut is associated with having more close friends of same sex in male participants (OR 1.05, 95% CI 1.01- 1.10) (Stephenson et al., 2014); having more close friends of opposite sex in females (OR 1.19, 95% CI 1.05-1.36) (Stephenson et al., 2014).

Table 4-6 Studies describing association between various exposures and early sexual debut

Exposure type	Exposure	OR 95% CI (as reported in the paper unless otherwise stated)	Sex	Author
Connectedness	Family connectedness	(-0.071) [D]	Both	Handebo, S., et al. (2018)
Peer interaction	Having more close friends of same sex	0.83 (0.71 - 0.96)[A]	Female	Stephenson et al. (2014).
	Having more close friends of same sex	1.05 (1.01 - 1.10)[A]	Male	Stephenson et al. (2014).
	Having more close friends of opposite sex	0.8 (0.4 - 1.2)[A]	Male	Kuzman, M., et al. (2007)
	Having more close friends of opposite sex	1.3 (0.9 - 1.9)[A]	Female	Kuzman, M., et al. (2007)
	Having more close friends of opposite sex	1.19 (1.05 - 1.36)[A]	Female	Stephenson et al. (2014).
	Number of evening spending with friends (more than 4 days/ less than 4 days)	0.85[E]	Both	Mladenovik, B., et al. (2010)
	Number of days spent with friends (more than 4 days/ less than 4 days)	0.99[E]	Both	Mladenovik, B., et al. (2010)
Internet use	Those who were pressured into sexting/ those who were not pressured into sexting	8.4[E]	Both	Van Ouytsel (2021)
	Those with a history of internet use/ those without the history of internet use	0.58 (0.5-0.68)[A]	Female	Alhassan (2021)

A- Adjusted OR,
B- Adjusted OR (95% CI), but 95% is calculated by the reviewer.
C- Derived from the beta value by reviewer, unable to calculate 95% CI,
D- correlation coefficient
E- Derived from the numbers by the reviewer

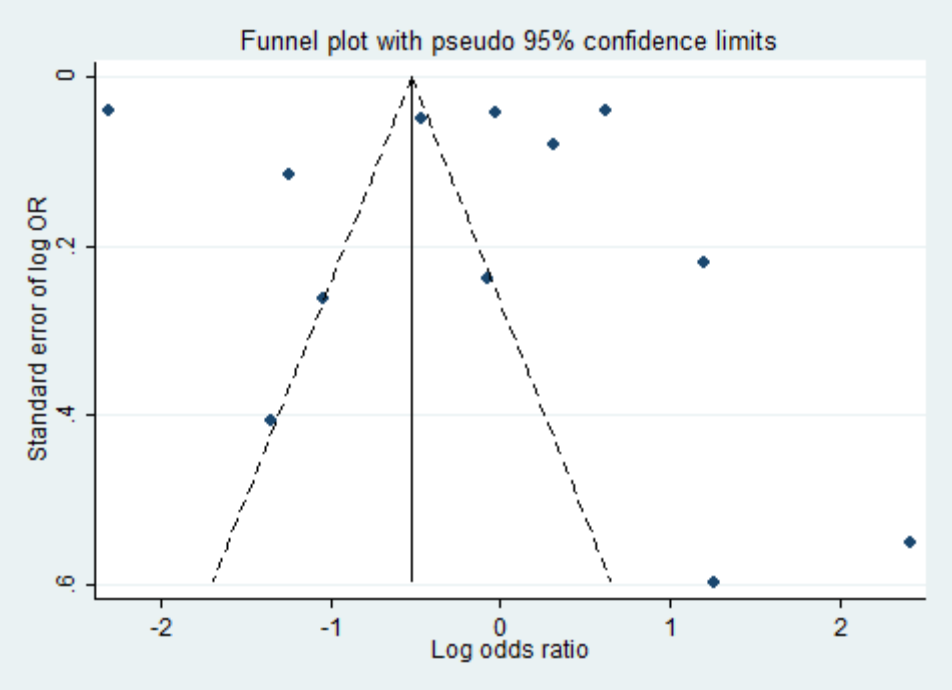


Figure 4-3 Funnel plot to assess the publication bias

Discussion

The objective of the review was to explore whether there is an association between social networks and ever having sex or early sexual behaviour among adolescents. Our review identified several studies that examine the relationship between connectedness and sexual activity in adolescence. We found that adolescents who reported a higher level of connection with their school were less likely to be sexually active. We also found that adolescents who had a stronger sense of connection to their mother, their father, or both parents were less likely to be sexually active. We also found that adolescents who perceived their peers to be sexually active were more likely to be sexually active themselves; we found that adolescents who use the internet for dating were also more likely to have had sexual experiences. Finally, we found that certain types of peer interactions were important in whether adolescents were more likely to have had an early sexual experience. However, the evidence is not sufficient to infer that these relationships are causal.

The connection with school and parents has meant adolescents have less chance to be sexually active. This may be due to the fact that adolescents begin to think about these values and beliefs based on those with whom they are connected because their brain function is not yet developmentally ready to logically handle decisions about sexual experiences and its consequences. Then, they gradually

establish their identities, which is the foundation for their adult experiences (ROGERS, 2013). Strong, positive family relationships and rewarding life events help young people strengthen their self-esteem. Secure and supportive attachments with parents help teens be more resilient (Baldwin & Hoffmann, 2002) Some previous studies showed that risky sexual behaviours were associated with less connectedness between youths and the school environment (Cherie & Berhane, 2012; Slap et al., 2003).

Young people who were aware that their peers were sexually active were more likely to follow suit. This may be due to the fact that adolescents' behaviours are guided by external social expectations. Social order has a huge impact on their decision-making according to Kohlberg's theory of moral development (Duska & Whelan, 1975). When they think that their peers were sexually active, they may also follow that sexual behaviour without remorse. Those participants who used the Internet to date were positively associated with having sex. This finding is consistent with the findings of a previous systematic review that explored the association between adolescents who viewed sexually explicit websites and pornography or enjoyed sexting and the likelihood of engaging in sexual experiences (L. W. Smith et al., 2016).

Peer interactions were found to be associated with the first sexual experience depending on the sex of adolescents. Girls with high peer acceptance or having more close friends of the same sex were less likely to be sexually active. However, girls with more close friends of the opposite sex were more likely to be sexually active. This pattern was not found in adolescent males: boys with high peer acceptance were more likely to be sexually active, boys with more close friends of the same sex were more likely to be sexually active, and boys with more close friends of the opposite sex were more likely to be sexually active. This could be due to the fact that girls are more aware of the perspectives of others, therefore they may suppress their own needs and feelings and are willing to balance their needs with those of their peers according to Gillian's theory of moral development (Gilligan, 1982). Social norms are different for girls/women than boys/young men (King, Rice, Schlichthorst, Chondros, & Pirkis, 2021). Another reason could be the digital gender gap between boys and girls in access and use of digital technologies and the Internet, that is, 58.3% in men vs 48.4% in women globally, 52.8% in men vs 40.7% in female in developing countries, and 87.6% in men vs 86.0% in female in developing countries (ITU, 2019). Furthermore, girls were more likely to use more intimate online platforms like Snapchat than boys, i.e., 42% vs. 29%, respectively. Snapchat is safer than other platforms because user profiles are only shared with the people with whom the user wants to connect (Monica Anderson, 2018).

Outcome level bias

Many original studies were conducted with large sample sizes in various countries both developed and developing with citizens of various ethnic and social backgrounds, except the study that involved adolescents with cerebral palsy, which had a small sample (Wiegerink et al., 2010). Therefore, the results of this review are rich, allowing generalization to diverse populations. However, there could be differential information bias in some cross-sectional studies because the researchers used unvalidated tools. It is unlikely that adolescents recall question about their first sexual experience incorrectly since this is a significant private life experience ; therefore, we assume that the chance of recall bias is likely low. Selection bias may not be a concern because all studies involved participants within the age range for adolescents (10-24) set by the Lancet Commission for Adolescents (Patton et al., 2016b), and most of the studies applied school-based recruitment, or household studies or nationwide randomly sampled studies. However, many studies did not report a response rate or compare demographic variables of nonrespondents vs. survey respondents. Furthermore, some of the studies did not control for possible confounders for sexual activity such as gender, ethnicity, and religion, though they did so

for age. One of the challenges in this review was the variety in working definitions for some of the exposures, especially for the more recent emerging concepts like social network density and use of the social networks. Therefore, we left most of the exposures without pooling. Heterogeneity was high in the subgroup meta-analysis because the measurement of outcomes varies across the original studies. We extracted the mean value from the original studies and the reviewer calculated 95% confidence intervals; and the range reproduced was narrower than 95% CI, which the original authors calculated adjusting for other confounders.

Ability to draw causal inferences from the findings

The strength of the correlations between exposures and outcomes had significant variation i.e., high statistical heterogeneity and therefore we could not pool the outcomes of some exposures. Furthermore, some exposures were reported in one study among the studies included in this systematic review. However, the strength of this review lies in the inclusion of four cohort studies and one case-control study, in addition to the 15 cross-sectional studies. Although cohort studies and cross-sectional studies were not analyzed separately due to limited exposure similarities, causal inference could be triangulated between the results of cohort studies and cross-sectional studies. Most of the studies in the meta-analysis were cohort studies in which exposures occurred before the results, and it confirmed the time order and causal inference. In terms of the methodology of each study, among the twenty studies involved in this review, 19 studies used the regression model controlling for relevant confounders. Therefore, it is plausible that connectedness to school, mother, father, and parents is protective against sexual activity in adolescence and that is of considerable importance for adolescent sexual health.

Reviewer-level biases

We acknowledge that our review has some limitations. As we did not cover unpublished studies, there was a potential for publication bias (I. Ahmed, Sutton, & Riley, 2012). There was an asymmetric funnel plot for all studies included in the meta-analysis; this could be due to publication bias or small-study effects (Sterne & Harbord, 2004). It could be more precise to test that effect if one funnel plot per each exposure category was applied. However, there were two to three studies for each exposure. To yield further detail on the heterogeneity, meta-regression should be applied. Unfortunately, there were not enough studies for each exposure to identify a particular study characteristic as the cause of heterogeneity. Furthermore, there could be a possible language bias because only English-language articles were included in the review (I. Ahmed et al., 2012). There might also be potential data availability bias, though we tried to mitigate this risk by requesting, up to three times via email, the essential data from the corresponding authors, but few authors did not respond.

In this study, reviewer selection bias was minimized by employing PRISMA, using a prospective meta-analysis approach, without contaminating the reviewer's knowledge of the subject with external preformed ideas.

Conclusion and future research

The available cohort studies and cross-sectional data suggest that connection to mother, father or school is negatively associated with having sex; but peer connection or peer interaction is associated with having sex or early sexual experience in either direction depending on the gender of adolescents. It seems that adolescents who are connected to parents and schools initiate their first sexual activity later than those who are not. More longitudinal studies would further explain the nature of that

relationship. Gender may act as a confounder or as an effect modifier; this should be considered in future studies that examine peer effects in adolescents.

Conflict of interest

None declared.

Study 2: Descriptive analysis findings

In this chapter, demographic variables, sexual behaviour variables and social network variables of the participants at three time points; baseline survey, midline survey and endline survey will be discussed. Sexual behaviour variables are vaginal sex status, anal sex status, age of first vaginal sex, age of anal sex and age of sex without condom, number of sexual partners, type of sexual partners, sex with condom, and experience of unwanted sex. Social network variables are degree centrality, betweenness centrality, efficiency, constraint, average tie strength, and ego density. Alters variables are type of people in the network, type of occupation of the people in the network, level of closeness of the people to the respondent in the network.

Demographic variables at baseline

There were 84 participants in the survey at the beginning of the study. The age of the participants at the beginning of the study ranged from 15 to 17 years; 22 participants (26%) were 15 years; 27 participants (32%) were 16 years, and 35 participants (42%) were 17 years, respectively. The majority (n=70; 85%) were born in Australia, while 12 (15%) were born outside Australia. Regarding the education of the participants, 75 (91%) were still students enrolled in high school, among them five participants (7%) were grade 9; 19 (25%) were grade 10; 31 (41%) were grade 11 and 20 (27%) were grade 12. Thirty-seven (49%) students reported excellent/very good school performance, while 38 (51%) reported good, below average, or poor school performance.

The education and employment status of the parents was also collected. According to the fathers' education, 47 (59%) reached the university level, while 32 (41%) of the fathers of the participants achieved TAFE or other qualifications. The majority of the fathers of participants worked full-time 60 (76%) while 19 (24%) worked part-time or others. Among mothers of the participants , 52 (63%) were university educated and 30 (37%) had a TAFE or some other qualification. More than half of the mothers of participants worked full-time 43 (53%) while the remaining 38 (47%) worked part-time or other. The socioeconomic index for areas (SEIFA) score was generally high in more than half of the participants because 47 (64%) scored above 80 and 37 (49%) scored less than 80. These variables are shown in Table 4.1 and Figures 6.1-6.8.

Table 4-7 Demographic variables of participants at baseline

Variable	Respondent sex- Male	Respondent sex- Female	Respondent sex- other gender	Total
Gender	19 (23%)	59 (70%)	6 (7%)	84
Age				

Variable	Respondent sex- Male	Respondent sex- Female	Respondent sex- other gender	Total
15 years	4 (18%)	17 (77%)	1 (5%)	22
16 years	10 (37%)	14 (52%)	3 (11%)	27
17 years	5 (14%)	8 (80%)	2 (6%)	35
Country of birth				
Australia	14 (20%)	50 (71%)	6 (9%)	70
Outside Australia	4 (33%)	8 (67%)	0 (0%)	12
School Enrolment Status				
Yes	15 (20%)	55 (73%)	5 (7%)	75
No	3 (43%)	3 (43%)	1 (14%)	7
Education (year of school at the time of baseline survey)				
Grade 9	2 (40%)	3 (60%)	0	5
Grade 10	5 (26%)	13 (68%)	1 (5%)	19
Grade 11	8 (23%)	20 (64%)	3 (10%)	31
Grade 12	0	19 (95%)	1 (5%)	20
School performance				
Excellent/very good	11 (29%)	24 (65%)	2 (5%)	37
Good or below average	4 (10%)	31 (82%)	5 (8%)	38
Employment status of respondent				
No, I do not have a job	4 (14%)	19 (68%)	5 (18%)	28
Yes, I work for payment or unpaid	14 (26%)	68 (72%)	1 (2%)	54
Education of father				

Variable	Respondent sex- Male	Respondent sex- Female	Respondent sex- other gender	Total
TAFE, High school, Did not complete high school, Not sure	8 (25%)	23 (72%)	1 (3%)	32
University	9 (19%)	33 (70%)	5 (11%)	47
Employment status of father				
working full time	13 (22%)	42 (70%)	5 (8%)	60
working part-time or others	4 (21%)	14 (74%)	1 (5%)	19
Education of mother				
TAFE, High school, Did not complete high school, Not sure	5 (17%)	23 (77%)	2 (7%)	30
University	13 (25%)	35 (67%)	4 (8%)	52
Employment status of mother				
working full time	9 (21%)	31 (72%)	3 (7%)	43
Working part-time, unemployed, on a disability pension, studying, doing unpaid work inside the home, not sure	9 (24%)	26 (68%)	3 (8%)	38
SES 2				
0 to 81.5	10 (27%)	26 (70%)	1 (3%)	37
Above 81.5	5 (13%)	29 (76%)	4 (11%)	37

In summary, most of the participants (85%) were born in Australia, all were high school students, and 50% were very good at school performance. Most of the participants (70%) were female, but half of the participants (51%) reported they were attracted to people of box sexes or same sex. Most of the participants (80%) were sexually active (having had sex at least once). The first age of vaginal sex was 15.32 and first age of anal sex was 15.9.

The participants characteristics from the current study are comparable to those from the national survey of secondary students and sexual health Australia 2021. The latter consisted of 65% of female

2 SES = Socio Economic status based on the socio economic index for areas

participants, 41% identified as LGBTQ, 60.6% of the participant reported having experienced of oral or vaginal or anal sex, the first age of vaginal sex 15.3 year and the first age of anal sex was 15.6 years (Power et al., 2021).

Sexual behaviours at baseline survey, midline survey, and end line survey

Data on vaginal sex status, anal sex status, age of first vaginal sex, age of first anal sex, age of first sex without condom, number of sexual partners, sex without condom, and experience of unwanted sex were also collected at baseline between early 2016 and mid-2016. Descriptive statistics are provided below.

At baseline, 42 participants (51%) reported that they were attracted to people of the opposite sex, while 40 (49%) reported that they were attracted to people of both sexes or the same sex. Most of the participants, 69 (80%) were sexually active while 17 (20%) were not sexually active (defined as having had sex at least once).

Vaginal sex status

The adolescents progressively participated in vaginal sex activities as they grew older. At the baseline survey, 39 (57%) out of 69 respondents reported that they engaged in vaginal sex while 44 (75%) of 59 respondents at the midline survey and 45 (80%) of 57 respondents at the end line survey did so, respectively, Figure (4.4).

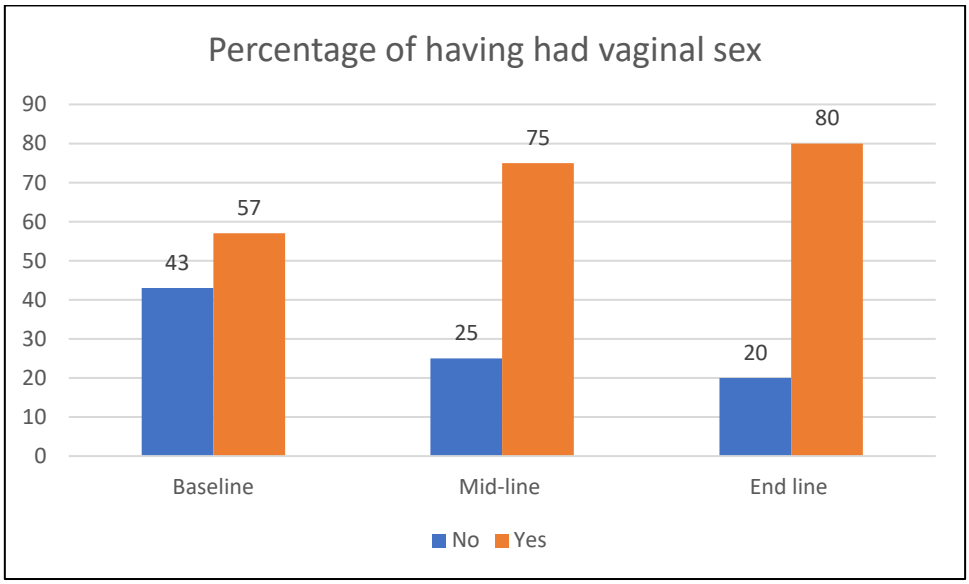


Figure 4-4 Comparison of percentage of active vaginal sex status in respondents across three time points

Anal sex status

The prevalence of anal intercourse among adolescents also increased as they grew older. Nearly one-fifth of the respondents at the beginning of the study, 13 (19%) out of 69 respondents, reported

having anal sex, while 17 (29%) of 59 in the midline survey and 14 (25%) of 57 in the end line survey did so, respectively, Figure (4.6).

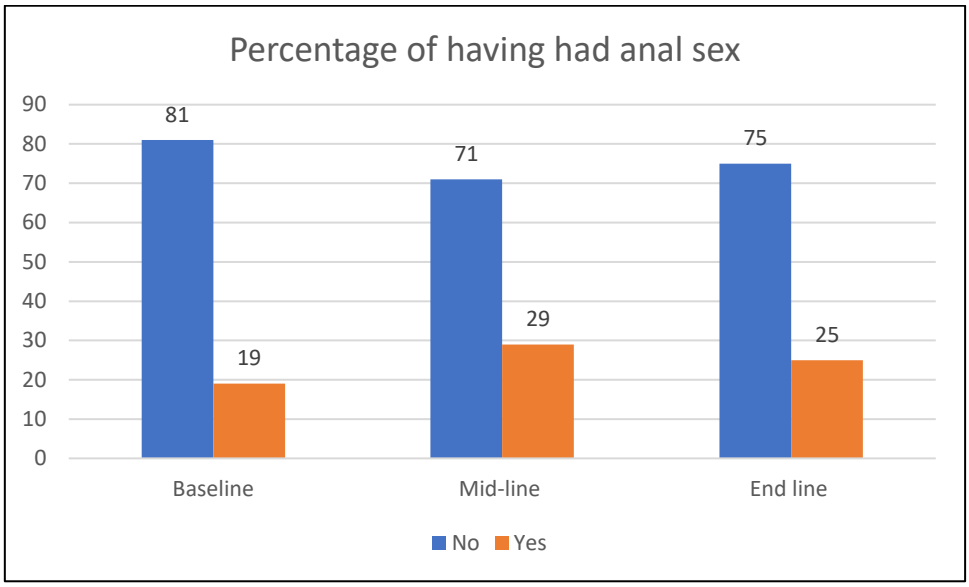


Figure 4-5 Comparison of percentage of active anal sex status in respondents across three time points

Age of first vaginal sex, anal sex and sex without condom

The mean age of first deep kiss was 14.12 years, the first touch to the genitals of others was 14.82, the first touch to the genital by others was 14.65, the first oral sex given to others was 14.96, the first receiving oral sex was 15.11, the first vaginal sex was 15.32, the first anal sex was 15.9, and the first sex without condom was 15.52, respectively, Figure (4.7).

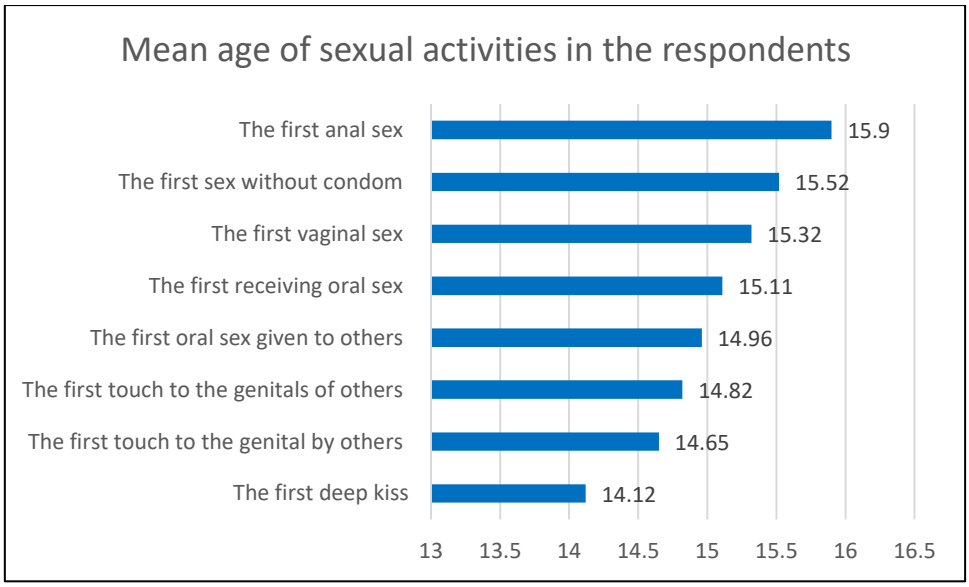


Figure 4-6 Mean age of sexual activities in the respondents

Taking 16 years old as the cut-off point for the early first vaginal or first anal sex, 19 (51%) of 37 respondents who were active in vaginal sex reported having first vaginal sex since under 16 years of age. Similarly, 3 (30%) of the 10 respondents who were active in anal sex reported that they engaged in the first anal sex under 16 years of age.

Number of sexual partners among sexually active respondents

More than half of the sexually active adolescents, 24 (60%) of 40 respondents, reported having one partner (vaginal or anal sex in the last six months before the survey), while 16 (40%) had multiple sexual partners at the beginning of the study. The percentage of multiple sexual partners increased progressively in T1-T2 (between baseline and midline survey) and T2-T3 (between midline and end line survey); 35 (48%) of 73 respondents and 35 (52%) of 67 respondents accordingly.

Type of sexual partners

Adolescents reported having more regular partners in T2-T3 compared to T1-T2. During T1-T2, 19 (39%) of 49 respondents had regular partners, while 30 (61%) had regular or casual partners, or casual partners alone. The percent of regular partners had increased during T2-T3, where 24 (43%) of 56 respondents reported having regular partners while 32 (57%) had regular or casual partners, or casual partners alone.

Sex with condom

Adolescents were less likely to use condoms in T1, however, they were more likely to do so as they grew older. At T1, 28 (65%) reported they had sex without condom, among 69 participants who were sexually active. However, the percentage of participants who had sexual activity without condom dropped to 22 (37%) of 59 sexually active adolescents in T1-T2 and 16 (30%) of 54 sexually active adolescents in T2-T3. Figure (4.8).

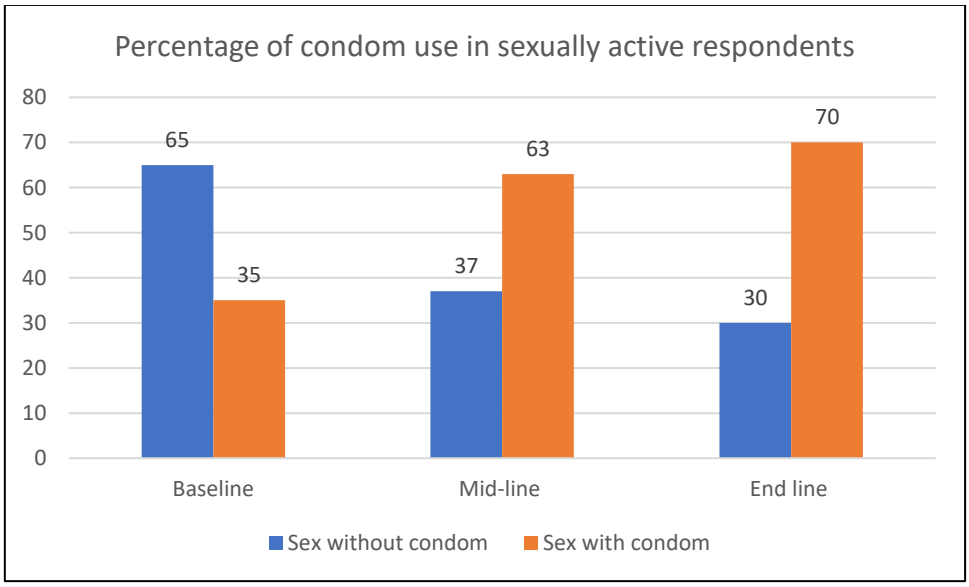


Figure 4-7 Comparison of percentage of sex with a condom in sexually active respondents across three time points

Experience of unwanted sex

Fourteen participants (32%) of 44 respondents who had had sex reported having had an experience of unwanted sex in their life at T1.

During the T1-T2 (between the midline survey and the end line survey) and the T2-T3 (midline survey and end line survey), similar questions were asked: 'How much did you want to have sex with this person' and 'How pleasant was it to have sex with this person?' In terms of how much the participants wanted sex per fortnight (score), the mean score of willingness was 82.76 (±13.68) at T1-T2 and 81.86 (±17.76) at T2-T3. These results showed that a minority of the participants experienced unwanted sex. In terms of how much they enjoyed the sex they had, the mean score of enjoyment was 77.6 (±19.84) at T1-T2 and 68 (±32) at T2-T3.

Table 4-8 Sexual behaviours of participants at baseline

Variables		Male	Female	Other	Total
Gender		19 (23%)	59 (70%)	6 (7%)	84 (100%)
Sexual attraction of Ego at baseline	Only to people of the opposite sex	11 (26%)	29 (69%)	2 (5%)	42 (100%)
	For the same sex, both sex or others	7 (18%)	29 (72%)	4 (10%)	40 (100%)
Vaginal sex status	No	10 (33%)	18 (60%)	2 (7%)	30 (100%)
	Yes	4 (10%)	32 (82)	3 (8%)	39 (100%)
Anal sex status at baseline	No	10 (18%)	42 (75%)	4 (7%)	56 (100%)
	Yes	4 (31%)	8 (62%)	1 (8%)	13 (100%)
Age of first vaginal sex	Under 16 years	2 (11%)	16 (84%)	1 (5%)	19 (100%)
	16 years and above	2 (11%)	14 (78%)	2 (11%)	18 (100%)

Variables		Male	Female	Other	Total
Age of first anal sex	Under 16 years	2 (67%)	1 (33%)	0	3 (100%)
	16 years and above	2 (25%)	5 (63%)	1 (12%)	8 (100%)
Age of first sex with no condom	Under 16 years	0	10 (91%)	1 (9%)	11 (100%)
	16 years and above	4 (25%)	12 (75%)	0	16 (100%)
Number of sexual partners at baseline (in the last six month, anal or vaginal)	One partner	4 (17%)	18 (75%)	2 (8%)	24 (100%)
	Multiple partners	3 (19%)	12 (75%)	1 (6%)	16 (100%)
Number of sexual partners at baseline (in last six month, anal or vaginal)	Mean, SD	3 (3)	2 (4)	1 (1)	2.29 (3.39)
	Minimum	1	0	0	0
	Median	1	1	1	1
	Maximum	8	17	2	17
Sex with no condom at baseline	No	3 (20%)	9 (60%)	3 (20%)	15 (100%)
	Yes	4 (14%)	23 (82%)	1 (4%)	28 (100%)
Unwanted sex in life	No	5 (17%)	21 (70%)	4 (13%)	30 (100%)
	Yes	2 (14%)	12 (86%)	0	14 (100%)

Table 4-9 Sexual behaviours of participants at time 1-2 (from baseline to midline) and time 2-3 (midline to end line)

Variable	Time 1-2 (baseline to midline)		Time 2-3 (midline to end line)	
Status of vaginal sex	No	15 (25%)	No	12 (21%)
	Yes	44 (75%)	Yes	45 (80%)
Status of anal sex	No	42 (71%)	No	43 (75%)
	Yes	17 (29%)	Yes	14 (35%)
Average number of sexual partners per fortnight				
	Mean, SD	1.52 (0.58)	Mean, SD	1.6 (0.67)
	Minimum	1	Minimum	1
	Median	1	Median	2
	Maximum	3	Maximum	4
Average number of sexual partners per fortnight (in category)	1	38 (52%)	Less than 2	32 (48%)
	2 to 3	35 (48%)	2 to 4	35 (52%)
Type of sexual partner	Regular	19 (39%)	Regular	24 (43%)
	Regular and casual, casual	30 (61%)	regular and casual, casual	32 (57%)
Average episodes of sex with a condom per fortnight	Mean, SD	1.32 (1.78)	Mean, SD	1.52 (1.84)
	Minimum	0	Minimum	0

Variable	Time 1-2 (baseline to midline)		Time 2-3 (midline to end line)	
	Median, Range	1 (0-9)	Median	1
	Maximum	9	Maximum	10
Average episodes of sex with a condom per fortnight (in category)	0	22 (37%)	0	16 (30%)
	1 and above	37 (63%)	1 to 10	38 (70%)
How much the participants wanted sex per fortnight (score)				
	Mean score, SD	82.76 (13.68)	Mean, SD	81.86 (17.76)
	Minimum score	49	Minimum score	7
	Median score	85	Median score	82
	Maximum score	100	Maximum score	100
How much the participants wanted sex per fortnight (score), categorised				
	Less than 85	27 (47%)	Less than 85	28 (50%)
	85 to 100	31 (53%)	85 to 100	28 (50%)
Average score of enjoying sex, categorised	Mean, SD	77.6 (19.84)	Mean, SD	68 (32)
	Minimum	0	Minimum	0
	Median	80.89	Median	79
	Maximum	100	Maximum	100
Average score of enjoying sex, categorised	Equal or less than 74.57	29 (51%)	Equal or less than 79.72	28 (51%)

Variable	Time 1-2 (baseline to midline)		Time 2-3 (midline to end line)	
	Greater than 74.57	28 (49%)	Greater than 79.72	27 (49%)

Social network variables at baseline, midline, and end line survey

Variables of social network: degree centrality, betweenness centrality, efficiency, constraint, tie strength, and ego density were collected at three time points T1 (baseline survey), T2 (midline survey) and T3 (end line survey). We used the median score of the variable as the cut-off point to create two groups for the comparison of low vs. high for each of the social network variables (Table 4.9, 4.10).

Degree centrality

The mean value and standard deviation of degree centrality in T1, T2, and T3 were 7.7 (2.2), 7.5 (1.97) and 7.6 (2.34). It showed that the number of connections of participants in the network did not fluctuate at three time points. However, the gap of degree centrality (maximum vs. minimum) became obvious at T3 because 10 vs. 3 at T1, 10 vs. 4 at T2, and 10 vs 0 at T3. It also found a similar trend in the categorical variable of degree centrality in which the high-degree and low-degree centrality were divided by the median score for the whole sample. Although the low degree centrality and high degree centrality categories were distributed equally 50% vs. 50% at T1 and T2, the low degree centrality at T3 occupied a larger portion; lower degree centrality 62% vs. higher degree centrality 38%. These findings suggested that some adolescents reduced their social connections when they matured.

Betweenness centrality

The mean (SD) of betweenness centrality in T1, T2 and T3 were 8.06 (9.72), 7.82 (8.86) and 6.18 (7.43), respectively. The maximum value of betweenness centrality also decreased across T2 and T3; 41 at T1, 31 at T2, and 36.5 at T3. In categorical variables where the median value was taken as a cutoff point; low betweenness centrality vs. high betweenness centrality changed significantly across three time points 50% vs. 50% at T1, 51% vs 48% at T2, and finally 55% vs. 45%. These findings suggested that adolescents were less likely to occupy high betweenness positions, as they grew older.

Efficiency

The mean value and standard deviation of efficiency centrality in T1, T2, and T3 were 0.47 (0.22), 0.47 (0.2), and 0.49 (0.2) respectively. Young people's efficiency were stable across the three time points. The point to note here was that the range between minimum and maximum efficiency value was large at three time points; 0.1 vs 0.92 at T1, 0.1 vs 1 at T2, and 0.1 vs 1 at T3. It suggested that the adolescents in the sample were very diverse in terms of efficiency in their social networks.

Constraints

The mean value and standard deviation of the constraint at T1, T2 and T3 were 0.44 (0.13), 0.44 (0.13) 0.45 (0.15). The constraint level in the network of adolescents was similar at three time points. However, the maximum value of constraint increased across the three time points; 0.65 at T1, 0.7 at T2, and 0.93 at T3. It showed that some of the adolescents in the sample experienced greater constraints in their communication with their social network members as they grew older. However, in the comparison of low-constraint vs. high-constraint categories, it showed that the low-constraint group was predominant at T3; 50% vs. 50% in T1, 47% vs 53% at T2 and 68% vs 32% at T3.

Average tie strength

The mean value and standard deviation of the average tie strength at T1, T2, and T3 were 7.9 (1.04), 7.6 (0.92) and 7.5 (0.83) respectively. Adolescents maintained the same level of intimacy and frequency of meeting with their connections throughout all three time points. Although the minimum value did not change, the median and maximum value dropped slightly at T2 and T3; median 8.12 at T1, 7.6 at T2 and 7.7 at T3; maximum 9.6 at T1, 9.5 at T2 and 9 at T3. The categorical variable (low average tie strength versus high average tie strength) showed that 50% vs. 50% at T1, 55% vs 45% at T2, and 54% vs 45% at T3. These data indicated that the adolescents became slightly more detached from their alters in the social network as they grew older.

Ego density

The mean value (SD) of the ego density at T1, T2 and T3 were 0.62 (0.26), 0.6 (0.26) and 0.63 (0.25) respectively. It revealed that the social networks in which the adolescents were embedded were on average, moderately dense at each time point.

However, the gap between the minimum and maximum value was high throughout all three time points; 0.09 vs. 1 at T1, 0 vs. 1 at T2, and 0.1 vs 1 at T3. It indicated that participants live in very diverse social networks, either 100% well connected or totally unconnected.

We took the median value as the cutoff point for categorizing the variable: high for values between the median and the maximum, and low for values between the median and minimum. For the degree centrality in the baseline survey, high degree centrality was the value between 7.5 (median value) and 10 (maximum value). For betweenness centrality at baseline survey, high was between 4.09 (median value) and 41 (maximum value). For efficiency in the baseline survey, high was between 0.52 (median value) and 0.92 (maximum value). For the constraint at baseline, high constraint was 0.43 (median value) and 0.65 (maximum value). For the average tie strength at baseline, high was 8.12 (median value) to 9.6 (maximum value). For ego density at baseline, high ego density was 0.6 (median value) to 1 (maximum value) (Table 4.10).

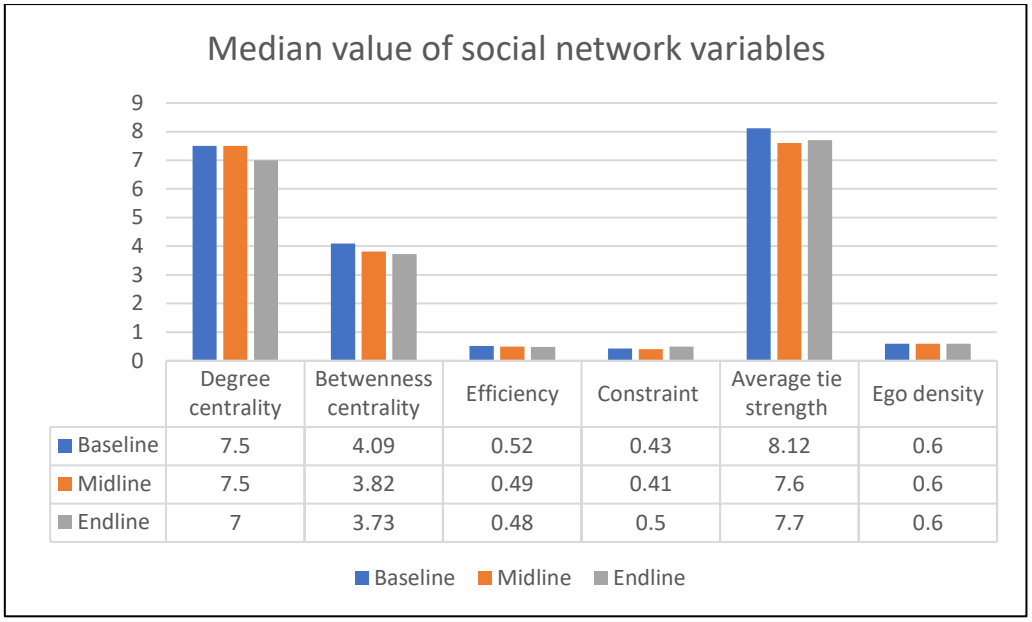


Figure 4-8 Comparison of median value of social network variables across three time points

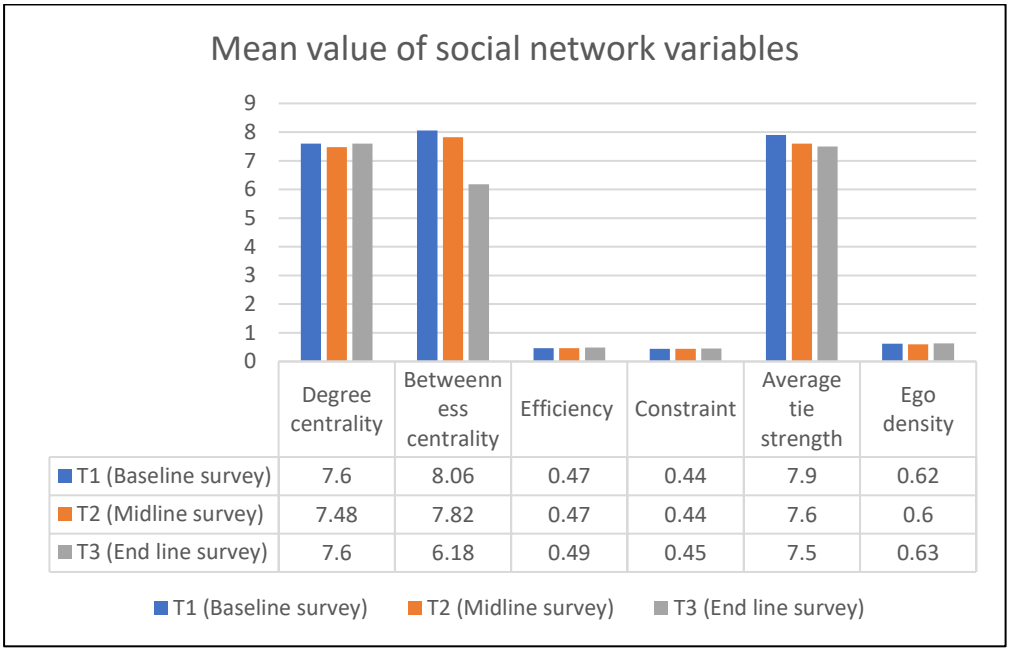


Figure 4-9 Comparison of median value of social network variables across three time points

Table 4-10 Social network variables at T1, T2 and T3

Social network variables	Measurement Unit	T1 (Baseline survey)	T2 (Midline survey)	T3 (End line survey)
Degree centrality	Minimum	3	4	0
	Median	7.5	7.5	7

Social network variables	Measurement Unit	T1 (Baseline survey)	T2 (Midline survey)	T3 (End line survey)
	Maximum	10	10	10
	Mean and SD	7.6 (2.2)	7.48 (1.97)	7.6 (2.34)
	Total respondents	78	62	53
Betweenness centrality	Minimum	0	0	0
	Median	4.09	3.82	3.73
	Maximum	41	31	36.5
	Mean and SD	8.06 (9.72)	7.82 (8.86)	6.18 (7.43)
	Total respondents	78	62	53
Efficiency	Minimum	0.1	0.1	0.1
	Median	0.52	0.49	0.48
	Maximum	0.92	1	0.92
	Mean and SD	0.47 (0.22)	0.47 (0.22)	0.49 (0.2)
	Total respondents	78	62	52
Constraint	Minimum	0.18	0.2	0
	Median	0.43	0.41	0.5
	Maximum	0.65	0.7	0.93
	Mean and SD	0.44 (0.13)	0.44 (0.13)	0.45 (0.15)
	Total respondents	78	62	53
Average tie strength	Minimum	5.3	5.3	5
	Median	8.12	7.6	7.7
	Maximum	9.6	9.5	9
	Mean and SD	7.9 (1.04)	7.6 (0.92)	7.5 (0.83)
	Total respondents	78	62	53

Social network variables	Measurement Unit	T1 (Baseline survey)	T2 (Midline survey)	T3 (End line survey)
Ego density	Minimum	0.09	0	0.1
	Median	0.6	0.6	0.6
	Maximum	1	1	1
	Mean and SD	0.62 (0.26)	0.6 (0.26)	0.63 (0.25)
	Total respondents	78	62	52

Table 4-11 Social network variables in category at T1, T2 and T3

	T1 (Baseline survey)		T2 (Midline survey)		T3 (End line survey)	
	Categories	Number of respondents	Categories	Number of respondents	Categories	Number of respondents
Degree centrality	0 to 7.5	39 (50%)	0 to 7.5	31 (50%)	0 to 7	33 (62%)
	7.5 to 10	39 (50%)	7.5 to 10	31 (50%)	7 to 10	22 (38%)
Betweenness centrality	0 to 4	39 (50%)	0 to 4	32 (512%)	0 to 4	29 (55%)
	4 to 41	39 (50%)	4 to 31	30 (48%)	4 to 36.5	24 (45%)
Efficiency	0 to 0.52	43 (55%)	0 to 0.49	31 (50%)	0 to 0.49	27 (52%)
	0.5 to 0.92	35 (45%)	0.49 to 1	31 (50%)	0.49 to 0.92	25 (48%)
Constraint	0 to 0.4	39 (50%)	0 to 0.4	29 (47%)	0 to 0.5	36 (68%)
	0.4 to 0.65	39 (50%)	0.4 to 0.65	33 (53%)	0.5 to 0.9	17 (32%)
Average tie strength	0 to 8.1	39 (50%)	0 to 7.6	34 (55%)	0 to 7.7	29 (54%)
	8.1 to 9.6	39 (50%)	7.6 to 9.5	28 (45%)	7.8 to 9	24 (45%)

	T1 (Baseline survey)		T2 (Midline survey)		T3 (End line survey)	
Ego density	0 to 0.6	46 (59%)	0 to 0.6	32 (52%)	0 to 0.6	27 (52%)
	0.6 to 1	32 (41%)	0.6 to 1	30 (48%)	0.6 to 1	25 (48%)

Alters variables at baseline, midline, and end line survey

Type of people in the network

Number of friends in the network

The mean (SD) of the number of friends in the networks out of ten people they nominated were 5 (± 2) or 6 (± 2) at all three times T1, T2 and T3. The number of friends in adolescents' networks varied substantially from 0 to 10 at each of the three time points T1, T2, and T3.

We categorized the number of friends in the network: (1) 5 friends or less and (2) six friends or more. The two-categories: less friends in the network vs more friends in the network changed substantially across three time points; 48% vs 52% at T1, 51% vs 49% at T2, and 63% vs 36% at T3. Young people had fewer friends in their networks across over time (Figure 4.11, 4.12, Table 4.12, 4.13).

Having boy/girlfriend in the network

The mean (SD) number of boy/girl friends of the respondents in the network was 1 (±1) at the three time points T1, T2, and T3. Some of the respondents did not have a boy / girlfriend on their networks, while some had 2-3 boy / girlfriends on their networks.

We categorized the number of boy/girl friends on the network: (1) no boy / girlfriend on the network and (2) having a boy / girlfriend on the network. Just under half of the respondents 37 (45%) out of 82 had a boy / girlfriend at the beginning of the study. The percentage increased at T2 and T3; 30 (48%) of 63 respondents; and 30 (55%) of 55 (Figure 4.11, 4.12, Table 4.12, 4.13).

Having family members in the network

The mean (SD) number of family members in the network was 1 (±1) at the three time points T1, T2, and T3. Some of the adolescents' social networks were mainly composed of family members, while others did not have family members in their networks. Interestingly, the maximum number of family members increased in the network as respondents grew older. Range, 0 to 3 at T1, 0 to 6 at T2, and 0 to 7 at T3. We categorized family members in the network: (1) no family member in the network and (2) having family members in the network. At T1, 41 (50%) of the 82 respondents reported that there was at least one family member in their network. At T2, 28 (44%) of 63 respondents and at T3, 31 (56%) of 55 respondents reported at least one family member. It revealed that adolescents experienced variation in the number of family members in their networks (Figure 4.11, 4.12, Table 4.12, 4.13).

Type of occupation of people in the network

Having high school students in the network

The number of high school students in the adolescents' network declined over time. The mean (SD) of high school students in the network were 5 (± 3) in T1, 4 (± 3) in T2, and 2 (± 2) in T3. Some respondents did not have any high school students in their networks. The range of number of high school students in the network varied considerably 0 to 10 at T1, 0 to 10 at T2, and 0 to 8 at T3.

We took the median value as the cutoff point for categorizing the variable: high for values between the median and the maximum, and low for values between the median and minimum. In the baseline and midline survey, the median values were five and four, while the median value of the number of high school students in the network of the respondents in the endline was zero.

The percentage of adolescents who did not have high school students in the network increased over time; 4 (5%) out of 82 at T1, 11 (17.46%) out of 63 in T2, and 21 (38%) out of 55 at T3, respectively (Figure 4.11, 4.12, Table 4.12, 4.13).

Having university students in the network

The mean (SD) of the number of university students in the networks of our study group was 1 (± 1) at T1, 2 (± 2) at T2, and 2 (± 2) at T3. The categories used were: (1) no university student in the network and (2) one or more university students in the network, and the latter percentage increased across time, 21 (26%) of 82 respondents at T1, 34 (54%) of 63 at T2 and 36 (65%) out of the 55 at respondents at T3 respectively (Figure 4.11, 4.12, Table 4.12, 4.13).

Having non-student workers in the network

In this study group, the mean number of nonstudents increased twice at T3, 1 (± 1) at T1, 1 (± 1) at T2 vs. 2 (± 2) at T3. The variable was classified as (1) no non-student worker in the network and (2) one or more non-student workers in the network. The percentage of non-student workers increased progressively in our study group as they grew older; 45 (55%) of 82 respondents at T1, 38 (60%) of 63 respondents at T2, and 45 (82%) of 55 respondents at T3 (Figure 4.11, 4.12, Table 4.12, 4.13).

Level of closeness of the people to the respondents in the network

Having very close people in the network

The mean number and SD of very close people in the network was similar in our study group for three time points; 3 (± 2) very close people at T1, T2, and T3. However, the percentage of very close people in the network decreased when we categorized by the median value. The number of very close people in the network was classified as (1) less than 3 and (2) equal or greater than 3 (the median value was 3 at all three time points). The percentage in 'equal or more than 3 very close people' dropped across the three time points; 50 (61%) of the total respondents at T1, 37 (59%) of 63 respondents at T2, and

15 (28%) of 55 respondents at T3. Respondents' networks went beyond very close people across time (Figure 4.11, 4.12, Table 4.12, 4.13).

Having close people in the network

The mean number and SD of close people was similar at three time points; 3 (± 2) at all T1, T2 and T3. However, the proportion of close people in the network had reduced. The number of close people in the network was classified into (1) less than 3 close people in the network and (2) 3 or more close people in the network according to the median value of 3 close people in the network. The percentage of respondents with '3 or more close people in the network' decreased across time; 55 (67%) of the total of 82 respondents at T1, 41 (65%) of the total of 63 respondents at T2, and 33 (60%) of the total of 55 respondents. It suggested that the adolescents' networks in this study changed as their age increased, with less close people in their networks (Figure 4.11, 4.12, Table 4.12, 4.13).

Having not really close people in the network

The mean number of people who were "not really close" in the network did not change across three time points; 1(± 1) at all T1, T2, and T3. "Not really close" people were categorized into (1) zero and (2) one or more. The percentage of respondents who had "not really close" people in their networks was relatively high at all three time points, 50 (61%) of the total respondents at T1, 41 (65%) of the total respondents at T2, and 33 (60%) of the total respondents at T3 (Figure 4.11, 4.12, Table 4.12, 4.13).

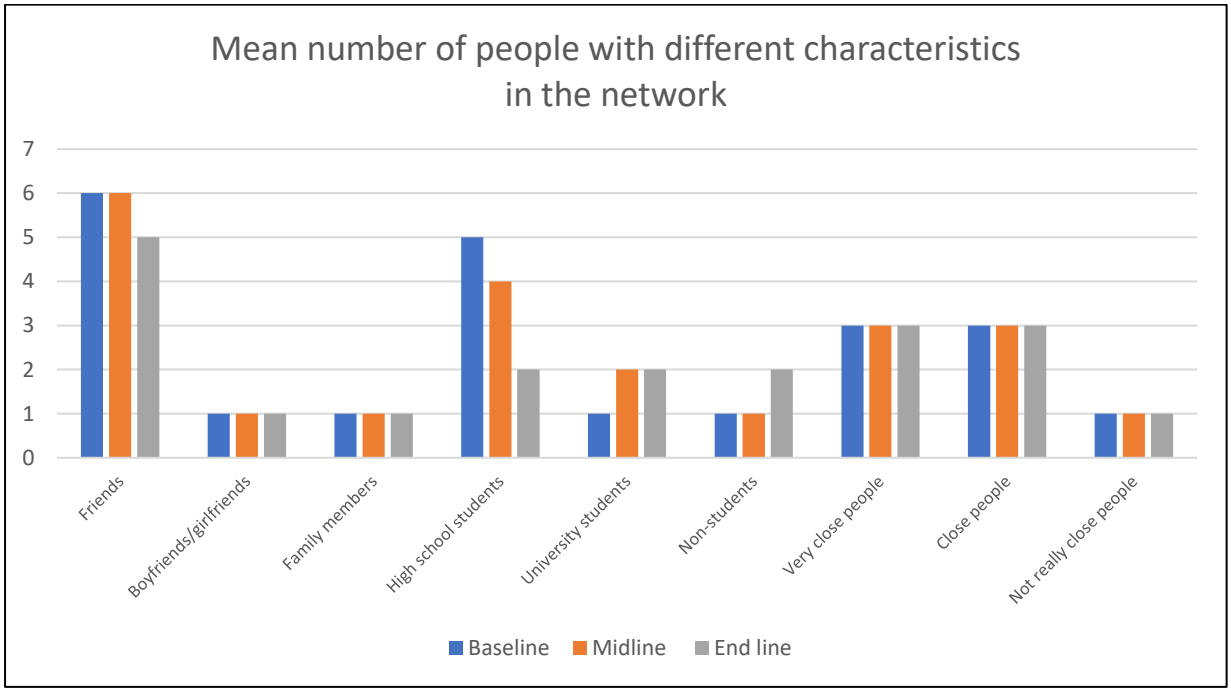


Figure 4-10 Comparison of mean number of people in the network in terms of type, occupation and closeness to the respondents at three time points

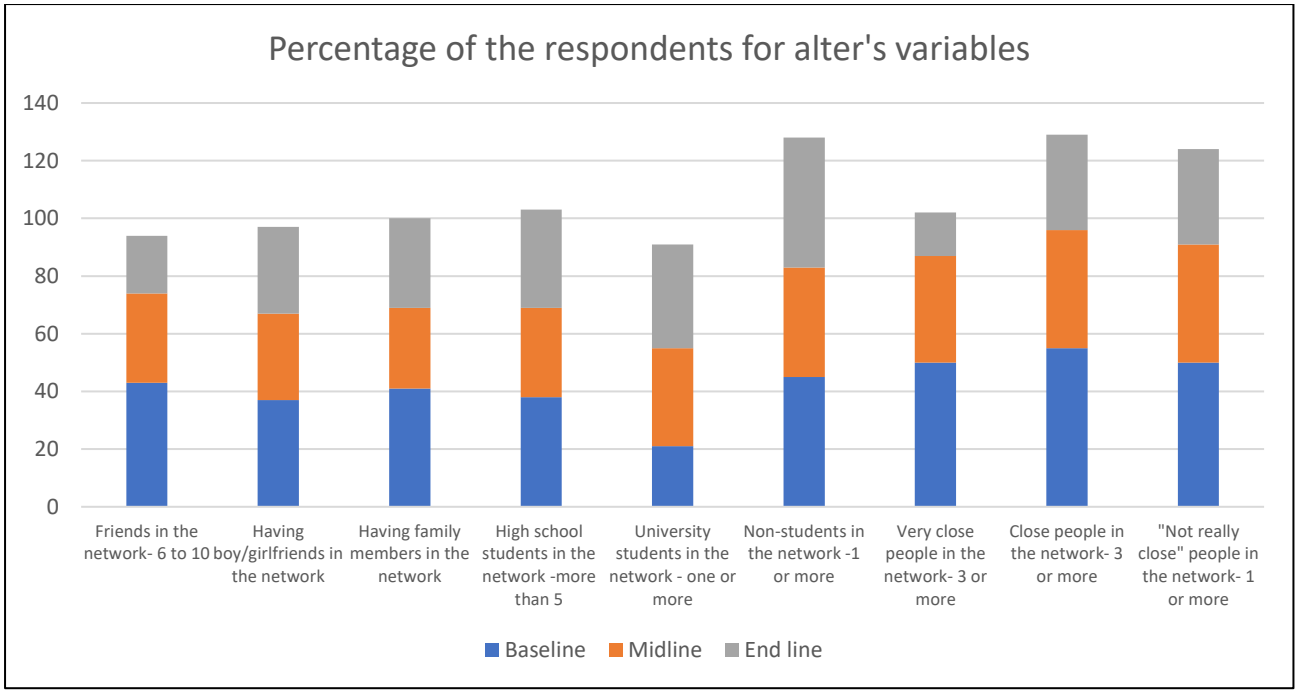


Figure 4-11 Comparison of percentage of respondents in terms of alters' variables at three time points

Table 4-12 Alter's variables as numerical variables at baseline, midline and end line survey

Variables	Categories	Baseline	Midline	End line
Number of respondents		82	63	55
Type of people in the network				
Friends in the network	Minimum	0	0	0
	Median	6	5	5
	Maximum	10	10	10
	Mean	6 (3)	6 (2)	5 (2)
Boy/girlfriends in the network	Minimum	0	0	0
	Median	0	0	1
	Maximum	3	2	2

Variables	Categories	Baseline	Midline	End line
	Mean	1 (1)	1 (1)	1 (1)
Family members in the network	Minimum	0	0	0
	Median	1	0	1
	Maximum	3	6	7
	Mean	1 (1)	1 (1)	1 (1)
Type of occupation				
High school students	Minimum	0	0	0
	Median	5	4	1
	Maximum	10	10	8
	Mean	5 (3)	4 (3)	2 (2)
University students	Minimum	0	0	0
	Median	0	1	1
	Maximum	7	9	7
	Mean	1 (1)	2 (2)	2 (2)
Non-student workers	Minimum	0	0	0
	Median	1	1	2
	Maximum	9	6	9
	Mean	1 (1)	1 (1)	2 (2)
Closeness				
Number of very close people in the network	Minimum	0	0	0
	Median	3	3	3
	Maximum	8	9	7

Variables	Categories	Baseline	Midline	End line
	Mean	3 (2)	3 (2)	3 (2)
Number of close people in the network	Minimum	0	0	0
	Median	3	3	3
	Maximum	8	8	7
	Mean	3 (2)	3 (2)	3 (2)
Number of not really close people in the network	Minimum	0	0	0
	Median	1	1	1
	Maximum	5	5	7
	Mean	1 (1)	1 (1)	1 (1)

Table 4-13 Alter's variables as categories at baseline, midline and end line survey

Variables	Categories	Baseline	Midline	End line
Number of respondents		82	63	55
Type of people in the network				
Friends in the network	5 or lower	39 (48%)	32 (51%)	35 (63%)
	6 to 10	43 (52%)	31 (49%)	20 (36%)
Boyfriend/girlfriends in the network	No boyfriend/girlfriends in the network	45 (55%)	33 (52%)	25 (45%)
	Yes boy/girlfriends in the network	37 (45%)	30 (48%)	30 (55%)

Variables	Categories	Baseline	Midline	End line
Family member in the network	No family member in the network	41 (50%)	35 (56%)	24 (44%)
	Family members in the network	41 (50%)	28 (44%)	31 (56%)
Type of occupation				
High school student				
	1-5 High school students in the network (1-4 at midline, 0 at end line)	44 (54%)	32 (51%)	21 (38%)
	More than 5 High school students in the network (more than 4 at midline, one or more at end line)	38 (46%)	31 (49%)	34 (62%)
	Having no high school student in the network	4 (5%)	11 (17%)	21 (28%)
University students	0 University student in the network	61 (74%)	29 (46%)	19 (35%)
	1 or more than one University students in the network	21 (26%)	34 (54%)	36 (65%)
Non-students	No non-student worker in the network	37 (45%)	25 (40%)	10 (18%)
	1 or more than one non-student workers in the network	45 (55%)	38 (60%)	45 (82%)
Closeness				
Number of very close people in the network	Less than 3	32 (39%)	26 (41%)	40 (72%)

Variables	Categories	Baseline	Midline	End line
	Equal or more than 3	50 (61%)	37 (59%)	15 (28%)
Number of close people in the network	Less than 3	27 (33%)	22 (35%)	22 (40%)
	Equal or more than 3	55 (67%)	41 (65%)	33 (60%)
Number of not really close people in the network	Zero	32 (39%)	22 (35%)	22 (40%)
	1 and above	50 (61%)	41 (65%)	33 (60%)

Study 3: Baseline analysis- social networks of the participants and their sexual behaviours

In the baseline analysis, in addition to the multiple logistic regression method, the correlation analysis was performed. The correlation analysis shows the relationships between demographic variables, social network variables, and sexual behaviour variables vice versa. Multiple logistic regression models at baseline analysis predict the association between social network variables (exposure variables) and sexual behaviour variables (outcome variables) at baseline survey controlling the potential confounders age, sex, sexual attraction, and SEIFA.

Social networks of the participants and their sexual behaviours (correlation)

There were significant correlations between the social network variables and sexual behaviours of participants.

Number of sexual partners was negatively associated with the density of ego $r = -0.35$, $p < 0.05$ and positively associated with efficiency $r = 0.36$, $p < 0.05$. This indicated that adolescents from the dense networks had a smaller number of sexual partners.

The experience of unwanted sex was positively associated with efficiency $r = -0.31$, $p < 0.05$. This indicated that adolescents with higher efficiency in the networks experienced more unwanted sex.

Also, there were significant associations between social network variables of participants. The average strength of the tie was positively associated with ego density $r = 0.7$, $p < 0.05$ and constraint $r = 0.42$, $p < 0.05$. Average tie strength was negatively associated with the degree centrality $r = -0.25$, $p < 0.05$, betweenness centrality $r = -0.59$, $p < 0.05$, and efficiency $r = -0.69$, $p < 0.05$. This indicated that adolescents from the networks with higher tie strength showed higher ego density, but lower number of people in the networks.

Degree centrality was positively associated with betweenness centrality $r = 0.59$, $p < 0.05$ and efficiency $r = 0.26$, $p < 0.05$ and negatively associated with constraint $r = -0.88$, $p < 0.05$. This indicated that adolescents with a greater number of people in the networks also showed higher efficiency, but lower constraints in the networks.

Betweenness centrality was positively associated with efficiency $r = 0.79$, $p < 0.05$ and negatively associated with constraint $r = -0.70$, $p < 0.05$. This indicated that adolescents with higher betweenness centrality also experienced higher efficiency in the networks.

Efficiency was negatively associated with constraint $r = -0.51$, $p < 0.05$. This indicated that adolescents with higher efficiency experienced lower constraint in the networks (Table 4-14).

Table 4-14 Correlations between social network attributes and sexual behaviours at baseline

	1. Age	2. Gender	3. Socio Economic Index For Areas	4. Number of partners	5. Experience of unwanted sex	6. Average tie strength	7. Ego density	8. Degree centrality	9. Betweenness centrality	10. Efficiency	11. Constraint
1. Age	1.00										
2. Gender	0.06	1.00									
3. Socio Economic Index For Areas	0.05	0.22	1.00								
4. Number of partners	-0.01	-0.04	-0.04	1.00							
5. Experience of unwanted sex	0.31	-0.10	-0.30	0.25	1.00						
6. Average tie strength	-0.13	-0.09	0.02	-0.22	-0.22	1.00					
7. Ego density	-0.13	-0.01	0.15	**-0.35***	-0.29	**0.7***	1.00				
8. Degree centrality	0.06	0.16	0.11	-0.11	-0.20	**-0.25***	**-0.37***	1.00			
9. Betweenness centrality	0.12	0.07	-0.03	0.25	-0.01	**-0.59***	**-0.81***	**0.59***	1.00		
10. Efficiency	0.14	-0.01	-0.17	**0.36***	**0.31 ***	**-0.69***	**-0.99***	**0.26***	**0.79***	1.00	
11. Constraint	-0.07	-0.17	-0.08	-0.03	0.16	**0.42***	**0.60***	**-0.88***	**-0.70***	**-0.51***	1.00

(-) shows negative association between variables.

* p value < 0

Social networks of the participants and their sexual behaviours (Logistic regression)

To test the association between social networks of respondents and their sexual behaviours at baseline, bivariate and multivariate logistic regression models were performed. Simple logistic regression was conducted for one exposure and one outcome in which the exposure variable was either a sociodemographic variable or a social network variable and the outcome variable was sexual behaviour. Then multiple logistic regression was performed for each social network variable (exposure) and each sexual behaviour (outcome) controlling for potential confounders. Exposure variables were selected by priori logic based on literature review, and these are age, sex, sexual attraction, and SEIFA; while social network variables are degree centrality, betweenness centrality, efficiency, constraint, average tie strength, and ego density. The outcome variables were active in vaginal sex, active in anal sex, number of the sexual partners, age of first vaginal sex, experience of unwanted sex and experience of sex without condom at baseline.

Vaginal sex status at the baseline survey in the logistic regression models

There were two categories of vaginal sex status: (1) non-active in vaginal sex (reference) and (2) active in vaginal sex as a comparison. The number and percentage of vaginal sex status is shown in Table 4.15

Simple logistic regression indicated that the vaginal sex status of the participants was associated with sex, the odds of having vaginal sex in females was 4.4 times higher than for males (OR= 4.4, 95% CI - 1.22, 16.23, p <0.05) (Table 4.15).

Table 4-15 Bivariate and multivariate logistic regression models of exposure variables on vaginal sex status at baseline[3]

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Age of Ego at baseline Under 16 years (Reference)	1	1	1	1	1	1	1
16 years and over	1.39 (0.43, 4.51)	1.09 (0.29, 4.11)	1.04 (0.27, 3.92)	1.18 (0.3, 4.49)	1.15 (0.30, 4.38)	1.23 (0.32, 4.75)	1.1 (0.29, 4.09)
Gender at baseline Male (Ref)	1						
Female	**4.4**						

[3] In bivariate logistic regression model exposure variable in each model is Age or Gender or Sexual attraction or SES of Ego at baseline or Degree centrality or Betweenness centrality or Efficiency or Constraint or Average tie strength or Ego density, and outcome variable is vaginal sex status at baseline.
In Multivariate logistic regression model 1, exposure variable is Degree centrality, outcome variable is vaginal sex status at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 2, exposure variable is Betweenness centrality, outcome variable is vaginal sex status at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 3, exposure variable is Efficiency, outcome variable is vaginal sex status at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 4, exposure variable is Constraint, outcome variable is vaginal sex status at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 5, exposure variable is Average tie strength, outcome variable is vaginal sex status at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 6, exposure variable is Ego density, outcome variable is vaginal sex status at baseline, and Age, Sexual attraction and SES are controlled in this model.

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
	(1.22, 16.23) *						
Sexual attraction of Ego at baseline Only to people of the opposite sex (Ref)	1	1	1	1	1	1	1
To same sex, both sex or others	0.95 (0.36, 2.46)	0.97 (0.33, 2.83)	1.01 (0.35, 2.97)	0.95 (0.36, 2.8)	1.01 (0.35, 2.91)	0.93 (0.32, 2.75)	1.04 (0.36, 3)
SES of Ego at baseline 0 to 81.5 (Ref)	1	1	1	1	1	1	1
Above 81.5	1.67 (0.61, 4.59)	1.67 (0.58, 4.85)	1.25 (0.41, 3.77)	1.39 (0.47, 4.08)	1.61 (0.56, 4.63)	1.57 (0.54, 4.53)	1.39 (0.46, 4.17)
Degree centrality 0 to 7.5 (Ref)	1	1					
7.5 to 10	0.69 (0.25, 1.86)	0.62 (0.21, 1.85)					
Betweenness centrality 0 to 4 (Ref)	1		1				
4 to 41	0.38		0.43				

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
	(0.14, 1.06)		(0.14, 1.29)				
Efficiency 0 to 0.52 (Ref)	1			1			
0.5 to 0.92	0.47 (0.17, 1.28)			0.49 (0.16, 1.47)			
Constraint 0 to 0.4 (Ref)	1				1		
0.4 to 0.65	1.45 (0.54, 3.94)				1.56 (0.53, 4.61)		
Average tie strength 0 to 8.1 (Ref)	1					1	
8.1 to 9.6	2 (0.73, 5.45)					2.07 (0.68, 6.28)	
Ego density 0 to 0.6 (Ref)	1						1
0.6 to 1	1.53 (0.56, 4.19)						1.53 (0.49, 4.78)

*p < 0.05, **p < 0.01, ***p < 0.00

Anal sex status at baseline survey in the logistic regression models

There were two categories of anal sex status: (1) non-active in anal sex (reference) and (2) active in anal sex (comparison).

The anal sex status of the participants was associated with sexual attraction, betweenness centrality, efficiency, and average tie strength in the simple logistic regression, and was associated with sexual attraction, efficiency, and constraint in the multiple logistic regression.

Simple logistic regression indicated that anal sex status was associated with sexual attraction of participants, the odds of having anal sex in those who were attracted to same sex, both sexes, or others were 4.44 times higher than those who were only sexually attracted to the opposite sex (OR- 4.4, 95% CI- 1.10, 17.92, p less than 0.05). Those who were more efficient were more likely to report having anal sex (OR 7.65, 95%CI 1.5, 38.99, p less than 0.05) than those who were less efficient. Those who had stronger tie strength were more likely to report having less anal sex (OR 0.16, 0.03, 0.84, p less than 0.05).

Multiple logistic regression suggested that those who were interested in both sexes were more likely to participate in anal sex than those who were interested in only the opposite sex (AOR- 8.32, 1.32, 52.56, p less than 0.05). It also showed that participants with higher efficiency were correlated with a higher chance of having anal sex, the odds of having anal sex in those with higher efficiency were 7.57 times higher than those with low efficiency (AOR-7.57, 95% CI 1.19, 47.91, p less than 0.05), controlling for age, gender, sexual attraction, and SEIFA. It also suggested that higher constraint was correlated with a lower chance of having anal sex, the odds of having anal sex in those who had higher constraint were 0.13 times lower than those who had lower constraint (AOR- 0.13, 95% CI 0.02, 0.85, p less than 0.05), controlling for age, gender, sexual attraction and SEIFA. This indicated that adolescents with higher efficiency or lower constraints were associated with having anal sex (Table 4.16).

Table 4-16 Bivariate and multivariate logistic regression of study variables by the anal sex status at baseline[4]

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
		Model 1	Model 2 OR	Model 3	Model 4	Model 5	Model 6
Age of Ego at baseline Under 16 years (Ref)	NA	NA	NA	NA	NA	NA	NA
Sexual attraction of Ego at baseline Only to people of the opposite sex (Ref)	1	1	1	1	1	1	1
To same sex, both sex or others	**4.44** **(1.10, 17.92) ***	**8.32** **(1.32, 53.56)**	**6.74** **(1.19, 37.98)**	**8.25** **(1.35, 50.51)**	**10.65** **(1.64, 69.21)**	**0.8** **(0.16, 3.75)**	**6.47** **(1.15, 36.25)**
SES of Ego at baseline 0 to 81.5 (Ref)	1	1	1	1	1	1	1
Above 81.5	0.74 (0.20, 2.74)	0.51 (0.1, 2.7)	0.9 (0.19, 4.21)	1.03 (0.21, 5.28)	0.52 (0.1, 2.75)	0.8 (0.16, 3.75)	1.01 (0.21, 4.90)

[4] In bivariate logistic regression models, exposure variable in each model is Age or Gender or Sexual attraction or SES of Ego at baseline or Degree centrality or Betweenness centrality or Efficiency or Constraint or Average tie strength or Ego density, and outcome variable is anal sex status at baseline.
In Multivariate logistic regression model 1, exposure variable is Degree centrality, outcome variable is anal sex status at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 2, exposure variable is Betweenness centrality, outcome variable is anal sex status at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 3, exposure variable is Efficiency, outcome variable is anal sex status at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 4, exposure variable is Constraint, outcome variable is anal sex status at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 5, exposure variable is Average tie strength, outcome variable is anal sex status at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 6, exposure variable is Ego density, outcome variable is anal sex status at baseline, and Age, Sexual attraction and SES are controlled in this model.

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
Degree centrality 0 to 7.5 (Ref)	1	1					
7.5 to 10	1.63 (0.43, 6.20)	2.69 (0.47, 15.33)					
Betweenness centrality 0 to 4 (Ref)	1		1				
4 to 41	**2.03 (0.53, 7.75)***		2.27 (0.47, 10.99)				
Efficiency 0 to 0.52 (Ref)	1						
0.5 to 0.92	**7.65 (1.5, 38.99)***			**7.57 (1.19, 47.91)***			
Constraint 0 to 0.4 (Ref)	1						
0.4 to 0.65	0.21 (0.04, 1.05)				**0.13 (0.02, 0.85)***		
Average tie strength 0 to 8.1 (Ref)	1					1	
8.1 to 9.6	**0.16 (0.03, 0.84)***					0.18 (0.03, 1.11)	
Ego density 0 to 0.6 (Ref)	1						1

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
0.6 to 1	0.24 (0.05, 1.21)						0.28 (0.05, 1.74)

*p < 0.05, **p < 0.01, ***p < 0.0

Number of sexual partners at baseline survey in the logistic regression models

There were two categories for the number of sexual partners (1) one partner (reference) and (2) multiple sexual partners. The number of sexual partners was associated with efficiency in both single logistic regression and multiple logistic regression while with ego density in the multiple logistic regression.

Those who had higher efficiency were more likely to have multiple sexual partners than those who had lower efficiency, the odds of having multiple sexual partners in those who had higher efficiency were 4.44 times higher than in those who had lower efficiency (OR- 4.44, 95% CI 1.11, 17.67, p less than 0.05) in bivariate logistic regression model. Similarly, in multiple logistic regression models, the odds of having multiple sexual partners in those who had higher efficiency were 9.52 times higher than those who had lower efficiency (AOR- 9.52, 95% CI 1.36, 66.79, p less than 0.05).

The density of ego was another variable that was correlated with the number of sexual partners. Those who had higher ego density were less likely to have multiple sexual partners; in multiple logistic regression controlling for age, gender, sexual attraction and SEIFA of participants, the odds of having multiple sexual partners in those who had higher ego density were 0.07 times those who had a lower ego density score (AOR- 0.07, 95% CI 0.006, 0.77, p less than 0.05) (Table 4.17).

Table 4-17 Multivariate logistic regression of study variables by the number of sexual partners at baseline[5]

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Age of Ego at baseline Under 16 years (Ref)	1	1	1	1	1	1	1
16 years and over	0.43 (0.08, 2.24)	0.43 (0.069, 2.65)	0.27 (0.04, 1.84)	0.16 (0.2, 1.28)	0.29 (0.04, 2.08)	0.27 (0.04, 1.89)	0.11 (0.01, 1.33)
Gender at baseline Male (Ref)	1						
Female	0.89 (0.17, 4.70)						
Sexual attraction of Ego at baseline Only to people of the opposite sex (Ref)	1	1	1	1	1	1	1

[5] In bivariate logistic regression models, exposure variable in each model is Age or Gender or Sexual attraction or SES of Ego at baseline or Degree centrality or Betweenness centrality or Efficiency or Constraint or Average tie strength or Ego density, and outcome variable is the number of sexual partners at baseline.
In Multivariate logistic regression model 1, exposure variable is Degree centrality, outcome variable is the number of sexual partners at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 2, exposure variable is Betweenness centrality, outcome variable is the number of sexual partners at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 3, exposure variable is Efficiency, outcome variable is the number of sexual partners at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 4, exposure variable is Constraint, outcome variable is the number of sexual partners at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 5, exposure variable is Average tie strength, outcome variable is the number of sexual partners at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 6, exposure variable is Ego density, outcome variable is the number of sexual partners at baseline, and Age, Sexual attraction and SES are controlled in this model.

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
To same sex, both sex or others	1.97 (0.54, 7.17)	1.26 (0.29, 5.50)	1.22 (0.28, 5.38)	1.82 (0.36, 9.27)	1.43 (0.33, 6.11)	1.59 (0.35, 7.24)	1.75 (0.35, 8.72)
SES of Ego at baseline 0 to 81.5 (Ref)	1	1	1	1	1	1	1
Above 81.5	0.75 (0.19, 2.92)	0.67 (0.16, 2.76)	1.10 (0.22, 5.42)	1.28 (0.24, 6.82)	0.67 (0.16, 2.81)	0.82 (0.19, 3.65)	1.66 (0.3, 9.24)
Degree centrality 0 to 7.5 (Ref)	1	1					
7.5 to 10	0.65 (0.18, 2.37)	1.06 (0.22, 5.11)					
Betweenness centrality 0 to 4 (Ref)	1		1				
4 to 41	2.92 (0.77, 11.07)		4.57 (0.86, 24.38)				
Efficiency 0 to 0.52 (Ref)							
0.5 to 0.92	**4.44 (1.11, 17.67)***			**9.52 (1.36, 66.79)***			
Constraint 0 to 0.4 (Ref)	1				1		
0.4 to 0.65	0.93 (0.26, 3.41)				0.45 (0.08, 2.36)		
Average tie strength 0 to 8.1 (Ref)	1					1	

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
8.1 to 9.6	0.54 (0.15, 1.98)					0.37 (0.68, 2.01)	
Ego density 0 to 0.6 (Ref)	1						
0.6 to 1	0.28 (0.07, 1.14)						**0.07 (0.006, 0.77)***

*p < 0.05, **p < 0.01, ***p < 0.00

Age of first vaginal sex at baseline in the logistic regression models

There were two categories of age of first vaginal sex namely: (1) under 16 years of age (reference) and (2) 16 years and older. Age of first vaginal sex was associated with some social network variables: degree centrality and constraint of the participants in the simple logistic regression.

Having the first vaginal sex after 16 years of age in those who had greater degree centrality (number of people in the network) were 4.11 times higher in those who had lower degree centrality (OR- 4.11, 95% CI 1.02, 16.67, p = 0.05) in bivariate logistic regression.

Adolescents with a higher constraint in networks were less likely to have their first vaginal sex after 16 years of age than those with a lower constraint. The odds of having the first vaginal sex after 16 years in those with the higher constraint were 0.24 times those with the lower constraint (OR- 0.24, 95% CI 0.06, 0.98, p less than 0.05) in the bivariate logistic regression (Table 4.18).

Table 4-18 Bivariate logistic and multivariate logistic regression of study variables by age of first vaginal sex at baseline[6]

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Age of Ego at baseline Under 16 years (Ref)	NA	NA	NA	NA	NA	NA	NA
16 years and over							
Sexual attraction of Ego at baseline Only to people of the opposite sex (Ref)	1	1	1	1	1	1	1
To same sex, both sex or others	0.36 (0.1, 1.39)	0.33 (0.05, 2.01)	0.23 (0.05, 1.44)	1.41 (0.24, 8.28)	0.33 (0.05, 2.01)	0.24 (0.04, 1.41)	0.23 (0.04, 1.31)
SES of Ego at baseline 0 to 81.5 (Ref)	1	1	1	1	1	1	1
Above 81.5	3.44 (0.79, 15.02)	3.43 (0.59, 19.9)	4.14 (0.70, 24.38)	4.14 (0.70, 24.38)	3.43 (0.59, 19.92)	3.81 (0.68, 21.35)	3.43 (0.59, 19.9)

[6] In bivariate logistic regression model exposure variable in each model is Age or Gender or Sexual attraction or SES of Ego at baseline or Degree centrality or Betweenness centrality or Efficiency or Constraint or Average tie strength or Ego density, and outcome variable is age of first vaginal sex at baseline.
In Multivariate logistic regression model 1, exposure variable is Degree centrality, outcome variable is age of first vaginal sex at baseline, and Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 2, exposure variable is Betweenness centrality, outcome variable is age of first vaginal sex at baseline, and Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 3, exposure variable is Efficiency, outcome variable is age of first vaginal sex at baseline, and Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 4, exposure variable is Constraint, outcome variable is age of first vaginal sex at baseline, and Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 5, exposure variable is Average tie strength, outcome variable is age of first vaginal sex at baseline, and Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 6, exposure variable is Ego density, outcome variable is age of first vaginal sex at baseline, and Sexual attraction and SES are controlled in this model.

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
Degree centrality 0 to 7.5 (Ref)	1	1					
7.5 to 10	**4.11 (1.02, 16.67) ***	2.15 (0.34, 13.6)					
Betweenness centrality 0 to 4 (Ref)	1		1				
4 to 41	1.52 (0.40, 5.78)		1.41 (0.24, 8.28)				
Efficiency 0 to 0.52 (Ref)	1			1			
0.5 to 0.92	1.52 (0.39, 5.95)			1.41 (0.24, 8.28)			
Constraint 0 to 0.4 (Ref)	1				1		
0.4 to 0.65	**0.24 (0.06, 0.98) ***				0.47 (0.07, 2.95)		
Average tie strength 0 to 8.1 (Ref)	1					1	
8.1 to 9.6	0.66 (0.17, 2.49)					1.18 (0.20, 6.92)	
Ego density 0 to 0.6 (Ref)	1						1
0.6 to 1	0.99 (0.27, 3.66)						1.76 (0.29, 10.84)

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)

*p < 0.05, **p < 0.01, ***p < 0.00

Experience of unwanted sex at baseline survey in the logistic regression models

There were two categories of experience of unwanted sex: (1) no lifetime experience of unwanted sex (reference) and (2) having had experience of unwanted sex (comparison). Experience of unwanted sex was associated with ego density in simple logistic regression.

A higher score of ego density was associated with a decreased likelihood of experiencing unwanted sex; the odds of experiencing unwanted sex in those who had a higher ego density was 0.15 times lower than those who had a lower ego density (OR- 0.15, 95% CI 0.03, 0.8, $p < 0.05$) (Table 4.19).

Table 4-19 Multivariate logistic regression of study variables by the experience of unwanted sex at baseline [7]

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Age of Ego at baseline Under 16 years (Ref)	1	1	1	1	1	1	1
16 years and over	3.25 (0.35, 29.98)	4.08 (0.38, 43.31)	3.85 (0.37, 39.52)	3.23 (0.28, 37.35)	3.72 (0.33, 41.74)	2.56 (0.22, 30.14)	2.63 (0.21, 33.38)
Sexual attraction of Ego at baseline Only to people of the opposite sex (Ref)	1	1	1	1	1	1	1
To same sex, both sex or others	2.86 (0.73, 11.17)	2.87 (0.50, 16.33)	3.27 (0.65, 16.4)	3.41 (0.68, 17.11)	3.5 (0.65, 19.17)	4.04 (0.75, 21.78)	3.96 (0.74, 21.28)
SES of Ego at baseline	1	1	1	1	1	1	1

[7] In bivariate logistic regression model exposure variable in each model is Age or Gender or Sexual attraction or SES of Ego at baseline or Degree centrality or Betweenness centrality or Efficiency or Constraint or Average tie strength or Ego density, and outcome variable is the experience of unwanted sex at baseline.
In Multivariate logistic regression model 1, exposure variable is Degree centrality, outcome variable is the experience of unwanted sex at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 2, exposure variable is Betweenness centrality, outcome variable is the experience of unwanted sex at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 3, exposure variable is Efficiency, outcome variable is the experience of unwanted sex at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 4, exposure variable is Constraint, outcome variable is the experience of unwanted sex at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 5, exposure variable is Average tie strength, outcome variable is the experience of unwanted sex at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 6, exposure variable is Ego density, outcome variable is the experience of unwanted sex at baseline, and Age, Sexual attraction and SES are controlled in this model.

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
0 to 81.5 (Ref)							
Above 81.5	0.29 (0.70, 1.23)	0.31 (0.06, 1.42)	0.23 (0.04, 1.22)	3.41 (0.68, 17.11)	0.28 (0.06, 1.30)	0.32 (0.07, 1.56)	0.40 (0.08, 2.10)
Degree centrality 0 to 7.5 (Ref)	1	1					
7.5 to 10	0.58 (0.15, 2.21)	0.72 (0.13, 3.96)					
Betweenness centrality 0 to 4 (Ref)	1		1				
4 to 41	1.21 (0.33, 4.53)		0.55 (0.11, 2.9)				
Efficiency 0 to 0.52 (Ref)	1			1			
0.5 to 0.92	3.04 (0.78, 11.78)			1.57 (0.31, 7.85)			
Constraint 0 to 0.4 (Ref)	1				1		
0.4 to 0.65	0.92 (0.25, 3.41)				0.81 (0.16, 4.07)		
Average tie strength	1					1	

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
0 to 8.1 (Ref)							
8.1 to 9.6	0.27 (0.07, 1.1)					0.37 (0.07, 2.02)	
Ego density 0 to 0.6 (Ref)	1						1
0.6 to 1	**0.15 (0.03, 0.8)***						0.21 (0.03, 1.40)

*p < 0.05, **p < 0.01, ***p < 0.0

Experience of sex without condom at baseline survey in the logistic regression models

There were two categories of experience of sex without a condom: (1) no experience of sex without condom (reference) and (2) having experience of sex without condom (comparison).

Experience of sex without condom was mainly found in the participants with lower SEIFA scores in both in simple and multiple logistic regression. Those who had a higher SEIFA score were associated with a lower chance of having sex without a condom; the odds of sex without condom among those who had a higher SEIFA score were 0.10 time those who had a lower SEIFA score (OR- 0.10, 95% CI 0.02, 0.57, $p < 0.01$) in simple logistic regression. Adjusted for social network variables, the odds ratio was still significant (AOR= 0.10, 95% CI 0.02, 0.63, $p < 0.05$) (Table 4.20).

Table 4-20 Bivariate and multivariate logistic regression of study variables by the experience of sex with no condom at baseline[8]

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Age of Ego at baseline Under 16 years (Ref)	1	1	1	1	1	1	1
16 years and over	0.33 (0.03, 3.11)	1.16 (0.01, 2.84)	1.19 (0.01, 2.62)	0.21 (0.02, 2.86)	0.14 (0.01, 2.55)	0.6 (0.02, 3.56)	0.17 (0.01, 2.49)
Sexual attraction of Ego at baseline Only to people of the opposite sex (Ref)	1	1	1	1	1	1	1
To same sex, both sex or others	3.6 (0.96, 13.52)	3.01 (0.51, 17.72)	2.62 (0.51, 13.50)	2.41 (0.49, 11.88)	3.06 (0.53, 17.57)	2.32 (0.46, 11.7)	2.5 (0.5, 12.60)
SES of Ego at baseline 0 to 81.5 (Ref)	1	1	1	1	1	1	1

[8] In bivariate logistic regression model exposure variable in each model is Age or Gender or Sexual attraction or SES of Ego at baseline or Degree centrality or Betweenness centrality or Efficiency or Constraint or Average tie strength or Ego density, and outcome variable is the experience of sex with no condom at baseline.
In Multivariate logistic regression model 1, exposure variable is Degree centrality, outcome variable is the experience of sex with no condom at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 2, exposure variable is Betweenness centrality, outcome variable is the experience of sex with no condom at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 3, exposure variable is Efficiency, outcome variable is the experience of sex with no condom at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 4, exposure variable is Constraint, outcome variable is the experience of sex with no condom at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 5, exposure variable is Average tie strength, outcome variable is the experience of sex with no condom at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 6, exposure variable is Ego density, outcome variable is the experience of sex with no condom at baseline, and Age, Sexual attraction and SES are controlled in this model.

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
Above 81.5	**0.10 (0.02, 0.57)****	**0.10 (0.02, 0.63)***	**0.13 (0.02, 0.78)**	**0.01 (0.03, 0.74)**	0.10 (0.02, 0.64)	0.11 (0.02, 0.67)	0.14 (0.02, 0.84)
Degree centrality 0 to 7.5 (Ref)	1	1					
7.5 to 10	0.49 (0.13, 1.78)	1.92 (0.28, 13.12)					
Betweenness centrality 0 to 4 (Ref)	1		1				
4 to 41	2 (0.53, 7.49)		2 (0.35, 11.38)				
Efficiency 0 to 0.52 (Ref)	1			1			
0.5 to 0.92	2 (0.53, 7.49)			1.42 (0.26, 7.58)			
Constraint 0 to 0.4 (Ref)	1				1		
0.4 to 0.65	1.5 (0.41, 5.44)				0.45 (0.07, 2.99)		
Average tie strength 0 to 8.1 (Ref)	1					1	
8.1 to 9.6	0.88 (0.25, 3.12)					1.11 (0.20, 6.07)	
Ego density 0 to 0.6 (Ref)	1						1

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
0.6 to 1	0.46 (0.13, 1.69)						0.47 (0.08, 2.64)

*p < 0.05, **p < 0.01, ***p < 0.00

Summary of baseline analysis for the association between social networks of the participants and their sexual behaviours

Summary findings from the baseline data analysis of the association between social network variables of the participants and their sexual behaviour variables are:

- The odds of having vaginal sex in females was 4.4 times higher than for males (OR= 4.4, 95% CI - 1.22, 16.23, p <0.05). The odds of having anal sex in those who were attracted to same sex, both sexes, or others were 4.44 times higher than those who were only sexually attracted to the opposite sex (OR- 4.4, 95% CI- 1.10, 17.92, p less than 0.05).
- Those who had higher efficiency were correlated with a higher chance of having anal sex, the odds of having anal sex in those with higher efficiency were 7.57 times higher than those with low efficiency (AOR-7.57, 95% CI 1.19, 47.91, p less than 0.05).
- The odds of having multiple sexual partners in those who had higher efficiency were 9.52 times higher than those who had lower efficiency (AOR- 9.52, 95% CI 1.36, 66.79, p less than 0.05). The odds of having multiple sexual partners in those who had higher ego density were 0.07 times those who had a lower ego density score (AOR- 0.07, 95% CI 0.006, 0.77, p less than 0.05).
- Having the first vaginal sex after 16 years of age in those who had greater degree centrality (number of people in the network) were 4.11 times higher in those who had lower degree centrality (OR- 4.11, 95% CI 1.02, 16.67, p = 0.05).
- The odds of experiencing unwanted sex in those who had a higher ego density was 0.15 times lower than those who had a lower ego density (OR- 0.15, 95% CI 0.03, 0.8, p < 0.05).
- The odds of sex without condom among those who had a higher SEIFA score were 0.10 time those who had a lower SEIFA score (OR- 0.10, 95% CI 0.02, 0.57, p < 0.01).

Study 4: Midline analysis- social networks of the participants and their sexual behaviours

In the midline analysis, multiple logistic regression models predict the association between social network variables (exposure variables) and sexual behaviour variables (outcome variables) at midline survey controlling the potential confounders age, sex, sexual attraction, and SEIFA.

Type of sexual partners between baseline and midline surveys in the logistic regression models

There were two types of sexual partners in the analysis: 1) regular sexual partners only (reference) and 2) regular plus casual partners.

Types of sexual partners were associated with SES of participants, degree centrality, and constraint in bivariate logistic regression analysis and SES, degree centrality, betweenness centrality and constraint in multiple logistic regression analysis.

Those who had higher SES were more likely to have regular plus casual partners or casual partners only than those who had lower SES. The odds of having regular plus casual partners were 5.85 times higher for participants with higher SES compared with lower SES (OR 5.85, 95% CI 1.5, 22.8, $p < 0.05$). This association remained significant in multiple logistic regression models: (AOR- 5.51, 95% CI 1.18, 25.83, $p < 0.05$) after controlling age, sex, sexual attraction and degree centrality.

Those who had higher betweenness centrality were more likely to have regular or casual partners versus regular partners only than those who had lower betweenness centrality. The odds of having regular or casual partners in those who had higher betweenness centrality were 4.53 times higher than those who had a lower degree centrality (OR- 4.53, 95% CI 1.21, 16.96, $p < 0.05$). After controlling age, gender, and sexual attraction, the association between degree centrality and having regular or casual partners was still significant: (AOR- 6.78, 95% CI 1.28, 35.96, $p < 0.01$).

Similarly, adolescents with higher efficiency were more likely to report regular or casual partners vs regular partners only. The odds of having regular or casual partners in adolescents with high efficiency was 3.8 times higher than those with lower efficiency: (OR- 3.84, 95% CI 1.04, 14.21, $p < 0.05$).

Another significant finding was the association between the constraint and the type of sexual partners. Those who had a higher constraint were less likely to have regular or casual partners. In the multiple linear regression that controlled the age, gender, sexual attraction, SES, the odds of reporting regular or casual partners in participants with high constraint were 0.18 times those with low constraints (AOR- 0.18, 95% CI 0.3, 0.98, $p < 0.05$).

There was an association between ego density and type of sexual partners. Those who had high ego density were less likely to report regular or casual partners. In bivariate logistic regression, the odds of having regular or casual partners in adolescents with high ego density were 0.18 times lower than those with low constraints (OR- 0.26, 95% CI 0.07, 0.96, $p < 0.05$) (Table 4.21).

Table 4-21 Bivariate and multivariate logistic regression of study variables by the type of sexual partners (regular or regular plus casual) at midline survey [9]

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Age of Ego at baseline Under 16 years (Ref)	1	1	1	1	1	1	1
16 years and over	1.07 (0.26, 4.41)	0.98 (0.16, 5.92)	0.71 (0.12, 4.41)	0.89 (0.15, 5.41)	0.18 (0.03, 1)	0.99 (0.17, 5.9)	0.95 (0.16, 5.81)
Sexual attraction of Ego at baseline: Only to people of the opposite sex (Ref)	1	1	1	1	1	1	1
To same sex, both sex or others	0.69 (0.22, 2.19)	0.41 (0.09, 1.84)	0.31 (0.06, 1.6)	0.45 (0.10, 2)	0.32 (0.06, 1.62)	0.35 (0.07, 1.70)	0.48 (0.11, 2.11)
SES of Ego at baseline	1	1	1	1	1	1	1

[9] In bivariate logistic regression model exposure variable in each model is Age or Gender or Sexual attraction or SES of Ego at baseline or Degree centrality or Betweenness centrality or Efficiency or Constraint or Average tie strength or Ego density, and outcome variable is the type of sexual partners (regular or regular plus casual) at midline survey. In Multivariate logistic regression model 1, exposure variable is Degree centrality, outcome variable is the type of sexual partners (regular or regular plus casual) at midline survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 2, exposure variable is Betweenness centrality, outcome variable is the type of sexual partners (regular or regular plus casual) at midline survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 3, exposure variable is Efficiency, outcome variable is the type of sexual partners (regular or regular plus casual) at midline survey at baseline, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 4, exposure variable is Constraint, outcome variable is the type of sexual partners (regular or regular plus casual) at midline survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 5, exposure variable is Average tie strength, outcome variable is the type of sexual partners (regular or regular plus casual) at midline survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 6, exposure variable is Ego density, outcome variable is the type of sexual partners (regular or regular plus casual) at midline survey, and Age, Sexual attraction and SES are controlled in this model.

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
0 to 81.5 (Ref)							
Above 81.5	**5.85 (1.5, 22.82)***	3.44 (0.78, 15.17)	0.31 (0.06, 1.6)	**4.25 (1, 18.82)**	4 (0.09, 18.09)	**5.51 (1.18, 25.83)**	4.01 (0.89, 18.09)
Degree centrality 0 to 7.5 (Ref)	1	1					
7.5 to 10	1.95 (0.56, 6.73)	2.66 (0.57, 12.42)					
Betweenness centrality 0 to 4 (Ref)	1						
4 to 41	**4.53 (1.21, 16.96)***		**6.78 (1.28, 35.96)***				
Efficiency 0 to 0.52 (Ref)	1			1			
0.5 to 0.92	**3.84 (1.04, 14.21)***			3.50 (0.79, 15.45)			
Constraint 0 to 0.4 (Ref)	**1**						
0.4 to 0.65	0.4 (0.11, 1.41)				**0.18 (0.3, 0.98)***		

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
Average tie strength 0 to 8.1 (Ref)	1					1	
8.1 to 9.6	0.83 (0.24, 2.82)					0.31 (0.06, 1.60)	
Ego density 0 to 0.6 (Ref)	1						1
0.6 to 1	**0.26 (0.07, 0.96)***						0.23 (0.05, 1.04)

*p < 0.05, **p < 0.01, ***p < 0.001

Vaginal sex status between baseline and midline surveys

Vaginal sex status had two categories (1) no vaginal sex (reference) and (2) had vaginal sex between the baseline and midline survey.

Bivariate and multivariate analyses were performed with the study exposures: age, sex, sexual attraction, SES, degree centrality, betweenness centrality, efficiency, constraint, average tie strength, and the outcome: vaginal sex status between baseline and midline survey. However, there was no significant associations found between any of the above-mentioned exposures and the outcome.

Anal sex status between baseline and midline surveys in the logistic regression models

Anal sex status between the baseline and midline survey was classified into two: 1) No anal sex and 2) Yes, reported an experience of anal sex. Reporting anal sex was significantly related to sexual attraction, SES, the average tie strength and ego density of the participants, in binary and multiple logistic regression.

Those who were reported sexually attraction to both sexes or others, rather than only the opposite sex, were more likely to report anal sex. The odds of reporting anal sex in those who were attracted to both sexes or others were 3.9 times (OR- 3.9, 95% CI 1.16, 13.14, $p < 0.05$) higher than those who were only attracted to opposite sex, in the simple logistic regression.

The adolescents residing in high SES area were less likely to report experience of anal sex than those from the low SES area. The odds of adolescent reporting anal sex from the high SES area were 0.27 times those from low SES area in binary logistic regression (OR- 0.27, 95% CI 0.08, 0.92, $p< 0.05$). That association was still significant in the multiple logistic regression after controlling the age, gender, sexual attraction, and the social network variables: degree centrality, constraint, and tie strength. The odds of adolescents from high socioeconomic areas reporting anal sex were 0.20 times those from low socioeconomic areas, in the multiple logistic regression model (AOR-0.24, 95% CI 0.06, 0.98, $p<0.05$).

The odds of adolescents with a higher level of average tie strength reporting anal sex were 0.26 times those with a lower level of average tie strength (OR 0.21, 95% CI 0.07, 0.98, $p < 0.05$). That association was still significant after adjusting age, gender, sexual attraction, and SES (Table 4.22).

Table 4-22 Bivariate logistic regression of study variables on reporting anal sex between baseline and midline survey [10]

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Age of Ego at baseline Under 16 years (Ref)	1	1	1	1	1	1	1
16 years and over	1.27 (0.3, 5.42)	1.37 (0.25, 7.46)	1.3 (0.23, 6.85)	1.44 (0.26, 7.96)	5.5 (0.14, 2.11)	1.42 (0.25, 7.93)	1.45 (0.26, 7.98)
Sexual attraction of Ego at baseline Only to people of the opposite sex (Ref)	1	1	1	1	1	1	1
To same sex, both sex or others	**3.9 (1.16, 13.14)***	3.16 (0.76, 13.06)	2.69 (0.68, 10.72)	2.8 (7, 11.25)	2.8 (0.7, 11.18)	2.14 (0.51, 8.97)	2.9 (0.72, 11.59)
SES of Ego at baseline 0 to 81.5 (Ref)	1	1	1	1	1	1	1
Above 81.5	**0.27 (0.08, 0.92)***	0.29 (0.07, 1.16)	0.25 (0.06, 1.2)	**0.24 (0.06, 0.98)***	0.27 (0.07, 1.05)	0.29 (0.07, 1.16)	0.45 (0.06, 1)

[10] In bivariate logistic regression model exposure variable in each model is Age or Gender or Sexual attraction or SES of Ego at baseline or Degree centrality or Betweenness centrality or Efficiency or Constraint or Average tie strength or Ego density, and outcome variable is anal sex between baseline and midline survey. In Multivariate logistic regression model 1, exposure variable is Degree centrality, outcome variable is anal sex between baseline and midline survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 2, exposure variable is Betweenness centrality, outcome variable is anal sex between baseline and midline survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 3, exposure variable is Efficiency, outcome variable is anal sex between baseline and midline survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 4, exposure variable is Constraint, outcome variable is anal sex between baseline and midline survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 5, exposure variable is Average tie strength, outcome variable is anal sex between baseline and midline survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 6, exposure variable is Ego density, outcome variable is anal sex between baseline and midline survey, and Age, Sexual attraction and SES are controlled in this model.

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
Degree centrality 0 to 7.5 (Ref)	1	1					
7.5 to 10	0.53 (0.16, 1.8)	0.47 (0.12, 1.92)					
Betweenness centrality 0 to 4 (Ref)	1		1				
4 to 41	1.63 (0.49, 5.39)		1.6 (0.4, 6.4)				
Efficiency 0 to 0.52 (Ref)	1			1			
0.5 to 0.92	2.38 (0.70, 8.07)			2.26 (0.56, 9.18)			
Constraint 0 to 0.4 (Ref)	1				1		
0.4 to 0.65	0.61 (0.19, 2.03)				0.55 (0.14, 2.12)		
Average tie strength 0 to 8.1 (Ref)	1					1	
8.1 to 9.6	**0.26 (0.07, 0.98)***					0.33 (0.08, 1.42)	
Ego density 0 to 0.6 (Ref)	1						1

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
0.6 to 1	0.61 (0.19, 2.03)						0.53 (0.13, 2.14)

*p < 0.05, **p < 0.01, ***p < 0.001

Average episodes of sex with a condom per fortnight between baseline and midline surveys in the logistic regression models

There were two categories of average episodes of sex with a condom per fortnight, namely 1) no episode of sex with a condom and 2) one or more episodes of sex with a condom, among those who were sexually active. Bivariate and multivariate analyses were performed with the study exposures: age, gender, sexual attraction, SES, degree centrality, betweenness centrality, efficiency, constraint, average tie strength, and the outcome: average episodes of sex with a condom per fortnight between baseline and midline surveys. There was no significant association between each of these above-mentioned exposures and outcome.

How much the participants wanted sex per fortnight (score) between baseline and midline surveys in the logistic regression models

There were two categories of how much the participants wanted sex per fortnight (score), namely (1) score less than 85 and (2) score 85 to 100. Bivariate and multivariate analyses were performed with the study exposures: age, gender, sexual attraction, SES, degree centrality, betweenness centrality, efficiency, constraint, average tie strength, and the outcome: how much the participants wanted sex per fortnight (score) between baseline and midline surveys. There was no significant association between each of these above-mentioned exposures and outcome.

How much the participant enjoyed sex per fortnight (score) between baseline and midline surveys in the logistic regression models

There were two categories of average score of enjoying sex, namely (1) score less than 75 and (2) score 75 to 100. Bivariate and multivariate analyses were performed with the study exposures: age, gender, sexual attraction, SES, degree centrality, betweenness centrality, efficiency, constraint, average tie strength, and the outcome: how much the participants enjoyed sex per fortnight (score) between baseline and midline surveys. There was no significant association between each of these above-mentioned exposures and outcome.

Number of sexual partners per fortnight between baseline and midline surveys in the logistic regression models

There were two categories of average number of sexual partners per fortnight between baseline and midline survey: 1) one partner and 2) two partners and above. Bivariate and multivariate analyses were performed with the study exposures: age, gender, sexual attraction, SES, degree centrality, betweenness centrality, efficiency, constraint, average tie strength, and the outcome: average number of sexual partners per fortnight between baseline and midline surveys. There was no significant association between each of these above-mentioned exposures and outcome.

Summary of midline data analysis for the association between social networks of the participants and their sexual behaviours

Summary findings from the midline analysis of the association between social network variables of the participants and their sexual behaviours variables are:

The odds of having regular or casual partners in those who had higher betweenness centrality were 4.53 times higher than those who had a lower degree centrality (OR- 4.53, 95% CI 1.21, 16.96, $p < 0.05$). The odds of having regular or casual partners in adolescents with high efficiency was 3.8 times higher than those with lower efficiency: (OR- 3.84, 95% CI 1.04, 14.21, $p < 0.05$). The odds of having regular or casual partners in adolescents with high ego density were 0.18 times lower than those with low constraints (OR- 0.26, 95% CI 0.07, 0.96, $p < 0.05$)

The odds of reporting anal sex in those who were attracted to both sexes or others were 3.9 times (OR- 3.9, 95% CI 1.16, 13.14, $p < 0.05$) higher than those who were only attracted to opposite sex.

Study 5: End line analysis- social networks of the participants and their sexual behaviours

In the end line analysis, multiple logistic regression models predict the association between social network variables (exposure variables) and sexual behaviour variables (outcome variables) at end line survey controlling the potential confounders age, sex, sexual attraction, and SEIFA.

Type of sexual partners between midline and end-line surveys in the logistic regression models

There were two categories of sexual partners, namely 1) regular partners and 2) regular or casual partners. Bivariate and multivariate analyses were performed with the study exposures: age, sex, sexual attraction, SES, degree centrality, betweenness centrality, efficiency, constraint, average tie strength and the study outcome: the type of sexual partners between baseline and midline survey. However, there was no significant association between each of these exposures and outcome.

Vaginal sex status between midline and end-line surveys in the logistic regression models

There were two categories for the status of vaginal sex, namely: (1) no and (2) yes.

Bivariate and multivariate analyses were performed with the study exposures: age, sex, sexual attraction, SES, degree centrality, betweenness centrality, efficiency, constraint, average tie strength, and the outcome: type of vaginal sex status of participants between midline and endline surveys. There was no significant association between each of these exposures and outcome.

Anal sex status between midline and endline surveys in the logistic regression models

There were two categories of status for anal sex, namely: (1) no and (2) yes.

Bivariate and multivariate analyses were performed with the study exposures: age, sex, sexual attraction, SES, degree centrality, betweenness centrality, efficiency, constraint, average tie strength and tie strength and the outcome status of anal sex between midline and end line survey. However, there was no significant association between each of these previously mentioned exposures and outcome.

Average episodes of sex with a condom per fortnight between midline and endline surveys in the logistic regression models

There were two categories of average episodes of sex with a condom per fortnight between midline and endline surveys, namely: (1) no episode of sex with a condom per fortnight and (2) 1-10 average episodes.

Bivariate and multivariate analyses were conducted with study exposures: age, gender, sexual attraction, SES, degree centrality, betweenness centrality, efficiency, constraint, average tie strength, and the outcome average episodes of sex with a condom in the outcome per fortnight between the midline and the endline survey. There was no significant association between each of these above-mentioned exposures and outcome.

How much the participant wanted sex over previous fortnight (score)[11] between midline and endline surveys in the logistic regression models

There were two categories of reporting on how much participants wanted sex over the previous fortnight (score) 1) less than 85 and 2) 85 and above. Sexual attraction and average tie strength were significantly associated with score of how much the participants wanted sex as reported per fortnight (score) in adolescents between midline and end-line surveys.

Female adolescents had a lower odd of reporting a higher score of how much they wanted sex per fortnight compared to male adolescents (OR- 0.1, 95% CI 0.01, 0.86, p <0.05). The odds of reporting a higher score for wanting sex, in those who identified neither male nor female was 0.006 times that of male adolescents (OR 0.06, 95% CI 0.004, 0.92, p <0.05).

The odds of reporting a higher score for wanting sex, over previous fortnight, in those who had higher average tie strength, was 4.5 times those who had lower average tie strength (OR 4.5, 95% CI 1.31, 15.41, p < 0.05). This association remained significant in the multiple logistic regression after controlling age, sex, sexual attraction, SES: AOR 5.06, 95% CI 1.08, 23.57, p < 0.05 (Table 4.23).

[11] The average score is the score averaged over all the fortnights of follow up.

Table 4-23 Bivariate and multivariate logistic regression of study variables by average score of willingness to have sex between midline and end-line survey[12]

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Age of Ego at baseline Under 16 years (Ref)	1	1	1	1	1	1	1
16 years and over	1.22 (0.35, 4.24)	0.60 (0.12, 3.01)	0.96 (0.19, 4.96)	0.7 (0.13, 3.85)	0.69 (0.14, 3.34)	1.26 (0.21, 7.37)	0.74 (0.13, 4.16)
Gender at baseline Male (Ref)	1						
Female	**0.1 (0.01, 0.86)***						
Others (genders)	**0.06 (0.004, 0.92)***						
Sexual attraction of Ego at baseline Only to people of the opposite sex (Ref)	1	1	1	1	1	1	1

[12] In bivariate logistic regression model exposure variable in each model is Age or Gender or Sexual attraction or SES of Ego at baseline or Degree centrality or Betweenness centrality or Efficiency or Constraint or Average tie strength or Ego density, and outcome variable is average score of willingness to have sex between midline and end-line survey. In Multivariate logistic regression model 1, exposure variable is Degree centrality, outcome variable is average score of willingness to have sex between midline and end-line survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 2, exposure variable is Betweenness centrality, outcome variable is average score of willingness to have sex between midline and end-line survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 3, exposure variable is Efficiency, outcome variable is average score of willingness to have sex between midline and end-line survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 4, exposure variable is Constraint, outcome variable is average score of willingness to have sex between midline and end-line survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 5, exposure variable is Average tie strength, outcome variable is average score of willingness to have sex between midline and end-line survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 6, exposure variable is Ego density, outcome variable is average score of willingness to have sex between midline and end-line survey, and Age, Sexual attraction and SES are controlled in this model.

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
To same sex, both sex or others	1.78 (0.62, 5.12)	1.67 (0.46, 6.12)	3.19 (0.71, 14.53)	2.33 (0.56, 9.72)	2 (0.54, 7.35)	2.36 (0.59, 9.35)	2.25 (0.54, 9.31)
SES of Ego at baseline 0 to 81.5 (Ref)	1	1	1	1	1	1	1
Above 81.5	0.73 (0.24, 2.21)	0.43 (0.12, 1.54)	0.48 (0.13, 1.80)	0.49 (0.13, 1.81)	0.43 (0.12, 1.56)	0.32 (0.08, 1.30)	0.55 (0.15, 2.03)
Degree centrality 0 to 7.5 (Ref)	1	1					
7.5 to 10	1.02 (0.31, 3.35)	1.25 (0.30, 5.19)					
Betweenness centrality 0 to 4 (Ref)	1		1				
4 to 41	0.53 (0.16, 1.70)		0.23 (0.05, 1.11)				
Efficiency 0 to 0.52 (Ref)	1			1			
0.5 to 0.92	0.48 (0.15, 1.58)			0.33 (0.08, 1.41)			
Constraint 0 to 0.4 (Ref)	1				1		
0.4 to 0.65	1.78 (0.53, 6.02)				2 (0.53, 7.64)		
Average tie strength	1						

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
0 to 8.1 (Ref)							
8.1 to 9.6	**4.5 (1.31, 15.41)**					**5.06 (1.08, 23.57)***	
Ego density 0 to 0.6 (Ref)	1						1
0.6 to 1	2.02 (0.62, 6.55)						2.74 (0.64, 11.8)

*p < 0.05, **p < 0.01, ***p < 0.001

How much the participant reported enjoying sex per fortnight (average score) between midline and end-line surveys in the logistic regression models

There were two categories of scoring how much the participant enjoyed sex per fortnight, namely (1) less than 79.72 and (2) greater than 79.72. Average tie strength and efficiency were significantly associated with the higher average score, per fortnight, between midline and end-line surveys.

In participants who had a stronger tie strength, the odds of having a higher score of enjoying sex was 3.52 times those who had a weaker tie strength in the bivariate logistic regression (OR= 3.52, 95% CI 1.12, 11.06, $p < 0.03$).

Participants with higher efficiency in networks (adolescents who tap into diverse groups that are not connected to each other) had a lower odds of having higher score of how much they enjoyed sex per fortnight than those who had lower efficiency in networks (AOR= 0.23, 95% CI 0.066, 0.94, $p <0.05$) in the multiple logistic regression model adjusted for age, gender, sexual attraction, and SES (Table 4.24).

Table 4-24 Bivariate and multivariate logistic regression of study variables by average score of enjoying sex between midline and end line survey[13]

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Age of Ego at baseline Under 16 years (Ref)	1	1	1	1	1	1	1
16 years and over	0.59 (0.18, 1.95)	0.51 (0.11, 2.44)	0.82 (0.17, 4.00)	0.68 (0.13, 3.68)	0.67 (0.14, 3.21)	3.23 (0.82, 12.69)	0.6 (0.11, 3.28)
Gender at baseline Male (Ref)	1						
Female	0.42 (0.12, 1.45)						
Sexual attraction of Ego at baseline Only to people of the opposite sex (Ref)	1	1	1	1	1	1	1

[13] In bivariate logistic regression model exposure variable in each model is Age or Gender or Sexual attraction or SES of Ego at baseline or Degree centrality or Betweenness centrality or Efficiency or Constraint or Average tie strength or Ego density, and outcome variable is average score of enjoying sex between midline and end-line survey. In Multivariate logistic regression model 1, exposure variable is Degree centrality, outcome variable is average score of enjoying sex between midline and end-line survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 2, exposure variable is Betweenness centrality, outcome variable is average score of enjoying sex between midline and end-line survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 3, exposure variable is Efficiency, outcome variable is average score of enjoying sex between midline and end-line survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 4, exposure variable is Constraint, outcome variable is average score of enjoying sex between midline and end-line survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 5, exposure variable is Average tie strength, outcome variable is average score of enjoying sex between midline and end-line survey, and Age, Sexual attraction and SES are controlled in this model. In Multivariate logistic regression model 6, exposure variable is Ego density, outcome variable is average score of enjoying sex between midline and end-line survey, and Age, Sexual attraction and SES are controlled in this model.

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
To same sex, both sex or others	1.87 (0.69, 5.05)	2.12 (0.62, 7.24)	3.38 (0.84, 13.54)	3 (0.13, 3.68)	2.65 (0.73, 9.62)	2.69 (0.73, 9.83)	2.45 (0.64, 9.39)
SES of Ego at baseline 0 to 81.5 (Ref)	1	1	1	1	1	1	1
Above 81.5	0.89 (0.31, 2.5)	0.55 (0.17, 1.87)	0.55 (0.16, 1.93)	0.64 (0.18, 2.30)	0.5 (0.14, 1.75)	0.46 (0.13, 1.64)	0.65 (0.19, 2.26)
Degree centrality 0 to 7.5 (Ref)	1	1					
7.5 to 10	0.93 (0.30, 2.85)	1.1 (0.31, 4.03)					
Betweenness centrality 0 to 4 (Ref)	1		1				
4 to 41	0.52 (0.17, 1.58)		0.26 (0.06, 1.07)				
Efficiency 0 to 0.52 (Ref)	1			1			
0.5 to 0.92	0.34 (0.11, 1.08)			**0.23 (0.06, 0.94) ***			
Constraint 0 to 0.4 (Ref)	1				1		
0.4 to 0.65	2.62 (0.78, 8.82)				3.16 (0.82, 12.26)		

	Bivariate logistic regression model OR (95% CI)	Multivariate logistic regression models AOR (95% CI)					
Average tie strength 0 to 8.1 (Ref)	1					1	
8.1 to 9.6	**3.52 (1.12, 11.06)***					3.23 (0.82, 12.69)	
Ego density 0 to 0.6 (Ref)	1						1
0.6 to 1	1.72 (0.57, 5.22)						2.15 (0.54, 8.53)

*p < 0.05, **p < 0.01, ***p < 0.00

Number of sexual partners per fortnight between midline and end-line surveys in the logistic regression models

There were two categories of average number of sexual partners per fortnight between midline and endline surveys: (1) less than 2 partners and (2) 2 partners and above.

Bivariate and multivariate analyses were performed with the study exposures: age, gender, sexual attraction, SES, degree centrality, betweenness centrality, efficiency, constraint, average tie strength, and the outcome: average number of sexual partners per fortnight between midline and endline surveys. There was no significant association between each of these above-mentioned exposures and outcome.

Summary of end line data analysis for the association between social networks of the participants and their sexual behaviours

Summary findings from the end line data analysis of the association between social network variables of the participants and their sexual behaviours variables are:

- Female adolescents had a lower odd of reporting a higher score of how much they wanted sex per fortnight compared to male adolescents (OR- 0.1, 95% CI 0.01, 0.86, p <0.05).
- The odds of reporting a higher score for wanting sex, over previous fortnight, in those who had higher average tie strength, was 4.5 times those who had lower average tie strength (OR 4.5, 95% CI 1.31, 15.41, p < 0.05).
- In participants who had a stronger tie strength, the odds of having a higher score of enjoying sex was 3.52 times those who had a weaker tie strength (OR= 3.52, 95% CI 1.12, 11.06, p < 0.03).
- Participants with higher efficiency in networks had a lower odd of having higher score of how much they enjoyed sex per fortnight than those who had lower efficiency in networks (AOR= 0.23, 95% CI 0.066, 0.94, p <0.05).

Study 6: Longitudinal analysis (trend analysis) of social network variables of the participants and their sexual behaviours across baseline, midline, and end-line surveys

The trend analysis of the association between social network variables and sexual behaviours across time 1-2 (baseline to midline) and time 2-3 (midline to end line) was calculated by the generalized estimated equation model (GEE). The GEE model compared the variables of the same participant at different time points.

Number of sexual partners per fortnight by social network variables

There was no significant association between the social network variables and the number of sexual partners per fortnight. This result remained the same over the two-time periods (baseline-to-midline and midline to end-line).

Average episodes of sex with a condom per fortnight (binomial-odd ratio) by social network variables

There was no significant association between the variables of the social networks and episodes of sex with a condom per fortnight. This result remained the same over the two-time periods (baseline-to-midline and midline to end-line).

How much the participant wanted sex per fortnight (average score) by social network variables [14]

The score of how much the participant wanted sex per fortnight was associated with ego density, degree centrality, betweenness centrality, efficiency, and average tie strength.

Adolescents with a denser network (higher ego density) were more likely to report a higher score of wanted sex than those with a looser network (lower ego density) (the IRR was 1.09, 95% CI 1.04, 1.14, $p < 0.001$).

Those who had more connections (higher degree centrality) were less likely to report a higher score of wanted sex than those who had fewer connections (lower degree centrality) (IRR 0.94, 95% CI 0.9, 0.99, $p < 0.05$).

Adolescents who had higher betweenness centrality were less likely to report a higher score of wanted sex than those who had lower betweenness centrality (IRR 0.95, 95% CI 0.90, 0.99, $p < 0.05$).

Adolescents who had higher efficiency were less likely to report a higher score of wanted sex than those who had lower efficiency in the networks (IRR 0.95, 95% CI 0.90, 0.99, $p < 0.05$).

Adolescents who had stronger tie strength with people in the networks were more likely to report a higher score of wanted sex than those who had weaker tie strength with people in the networks (IRR 1.06, 95% CI 1.01, 1.11, $p < 0.05$). (Table 4.25)

How much the participant enjoyed sex per fortnight (average score) by social network variables

[14] [14] This score was calculated over two time periods; baseline to midline, and midline to endline.

The results demonstrated that how much the participant enjoyed sex per fortnight (average score) was associated with ego density, degree centrality, betweenness centrality, efficiency, constraint, and average tie strength. [15]

Participants with higher ego density, i.e., well-connected social networks, were more likely to report a higher score of enjoyed sex per fortnight than those with lower ego density, i.e, less connected social network (IRR 1.09, 95% CI 1.04, 1.15, $p < 0.01$).

Those who had a high degree of centrality (many connections) were more likely to report a higher score of enjoyed sex per fortnight than those who had a lower degree centrality (IRR - 1.006, 95% CI 1.01, 1.11, $p < 0.03$).

Participants who had high betweenness centrality were less likely to report a higher score of enjoyed sex per fortnight than those who had low betweenness centrality (IRR 0.91, 95% CI 0.87, 0.96, $p < 0.001$).

Respondents who were more efficient in the networks were less likely to report a higher score of enjoyed sex per fortnight than those who were less efficient (IRR 0.87, 95% CI 0.83, 0.91, $p < 0.00$).

Those who had higher constraint in their network were less likely to report higher score of enjoyed sex than those who had less constraint (IRR 0.91, 95% CI 0.87, 0.96, $p < 0.000$).

Adolescents who had a stronger tie strength with the people in their network were more likely to report a higher score of enjoyed sex than those who had weak ties with the people in their networks (IRR 1.08, 95% CI 1.03, 1.14, $p < 0.001$) (Table 4.25).

[15] This score was calculated over two time periods; baseline to midline, and midline to endline.

Table 4-25 GEE models for the outcome score of enjoying sex by the exposures social network variables

Incidence Rate Ratio	Number of sexual partners per fortnight	Time of having had sex per fortnight	Average episodes of sex with a condom per fortnight	How much the participant wanted sex per fortnight (score)	How much the participant enjoyed sex per fortnight (score)
Ego density					
0 to 0.6	1	1	1	1	1
above 0.6	0.9 (0.65, 1.27) (p= 0.58)	1.03 (0.81, 1.31) (p= 0.82)	0.75 (0.51, 1.11) (p= 0.15)	**1.09 (1.04, 1.14)** (p=0.001)**	**1.09 (1.04, 1.15)** (p= 0.001)**
Degree centrality					
0 to 8	1	1	1	1	1
above 8	0.96 (0.66, 1.34) (p=0.79)	0.86 (0.67, 1.11) (p=0.26)	1.04 (0.70, 1.53) (p= 0.85)	**0.94 (0.9, 0.99)* (p=0.02)**	**1.006 (1.01, 1.11)* (p=0.03)**
Betweenness centrality					
0 to 4.17	1	1	1	1	1
above 4.17	1.00 (0.72, 1.39) (p=0.98)	0.89 (0.7, 1.13) (p=0.34)	0.92 (0.64, 1.33) (p= 0.66)	**0.95 (0.90, 0.99) (p=0.02)***	**0.91 (0.87, 0.96)*** (p=0.00)**
Efficiency					
0 to 0.52	1	1	1	1	1
above 0.52	1.01 (0.73, 1.40) (p= 0.94)	0.92 (0.72, 1.17) (p= 0.49)	0.92 (0.64, 1.34) (p=0.68)	**0.95 (0.90, 0.99)* (p= 0.03)**	**0.87 (0.83, 0.91)*** (p=0.00)**
Constraint					
0 to 0.403	1	1	1	1	1
above 0.403	0.99 (0.72, 1.38) (p= 0.98)	1.25 (0.98, 1.58) (p=0.07)	1.20 (0.83, 1.74) (p= 0.32)	1.03 (0.98, 1.08) (p= 0.31)	**0.91 (0.87, 0.96)*** (p=0.00)**
Average tie strength					
0 to 8.1	1	1	1	1	1
above 8.1	0.97 (0.70, 1.35) (p=0.87)	1.01 (0.8, 1.29) (p=0.91)	0.95 (0.66, 1.37) (p= 0.8)	**1.06 (1.01, 1.11)* (p=0.01)**	**1.08 (1.03, 1.14)** (p=0.001)**

* p less than 0.05, ** p less than 0.01, *** p less than 0.001

Summary of longitudinal analysis for the association between social networks of the participants and their sexual behaviours

Summary findings from the longitudinal data analysis of the association between social network variables of the participants and their sexual behaviours variables are:

Adolescents with a denser network (higher ego density) were more likely to report a higher score of wanted sex than those with a looser network (lower ego density) (the IRR was 1.09, 95% CI 1.04, 1.14, p <0.001). Adolescents who had stronger tie strength with people in the networks were more likely to report a higher score of wanted sex than those who had weaker tie strength with people in the networks (IRR 1.06, 95% CI 1.01, 1.11, $p < 0.05$).

Adolescents who had higher betweenness centrality were less likely to report a higher score of wanted sex than those who had lower betweenness centrality (IRR 0.95, 95% CI 0.90, 0.99, $p < 0.05$). Adolescents who had higher efficiency were less likely to report a higher score of wanted sex than those who had lower efficiency in the networks (IRR 0.95, 95% CI 0.90, 0.99, $p < 0.05$).

Participants with higher ego density, i.e., well-connected social networks, were more likely to report a higher score of enjoyed sex per fortnight than those with lower ego density, i.e, less connected social network (IRR 1.09, 95% CI 1.04, 1.15, $p < 0.01$). Adolescents who had a stronger tie strength with the people in their network were more likely to report a higher score of enjoyed sex than those who had weak ties with the people in their networks (IRR 1.08, 95% CI 1.03, 1.14, $p < 0.001$)

Participants who had high betweenness centrality were less likely to report a higher score of enjoyed sex per fortnight than those who had low betweenness centrality (IRR 0.91, 95% CI 0.87, 0.96, $p < 0.001$). Respondents who were more efficient in the networks were less likely to report a higher score of enjoyed sex per fortnight than those who were less efficient (IRR 0.87, 95% CI 0.83, 0.91, $p < 0.00$).

Study 7: Baseline analysis of alter's variables and sexual behaviours of the participants

In the baseline line analysis, multiple logistic regression models predict the association between alters' variables (exposure variables) and sexual behaviour variables (outcome variables) at baseline survey controlling the potential confounders age, sex, sexual attraction, and SEIFA.

Vaginal sex status at baseline survey in the logistic regression models

There were two categories of vaginal sex status 1) vaginal sex non-active (reference) and 2) vaginal sex active. We examined whether the different kinds of people in the network were associated with the change in the status of vaginal sex. The results of the bivariate logistic regression model showed that the odds of being active in vaginal sex increased 6.5 times (OR 6.5, 95% CI 2.47, 17.08, p = 0.00) in those who had boy/girl friends on the network than those who did not. This kind of association remained significant in the multivariate logistic regression model that controlled Age, SEIFA, and sexual attraction; showing that being active in the vaginal sex increased 9 times (AOR 9.02, 95% CI 2.72, 30, p = 0.00) in those who had boy/girl friends in the network than those who did not have.

We also examined whether 1) different types of occupation of the people in the network and 2) different closeness levels of alters to the respondents were also associated with the change in the status of vaginal sex of adolescents in the sample, however there was no association for these variables (Table 4.26).

Table 4-26 Bivariate and multivariate logistic regression of vaginal sexual activity status (yes/no) by the type of people in the network at baseline[16]

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	2.14 (0.76, 6.04)	2.16 (0.7, 6.67)	3.47 (0.95, 12.66)	1.87 (0.63, 5.57)
Sexual attraction of Ego at baseline				
Attraction to only to people of the opposite sex				
Attraction to same sex, both or others	1.1 (0.46, 2.65)	1.20 (0.47, 3.19)	1.08 (0.38, 3.12)	1.17 (0.45, 3.01)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	1.65 (0.65, 4.16)	1.71 (0.69, 4.66)	2.84 (0.92, 8.75)	1.70 (0.66, 4.37)
Number of friends in the network				
1 to 5	1			
6 to 10	0.62 (0.25, 1.53)	0.50 (0.19, 1.35)		
Boyfriend/girlfriend in the network				
No				

[16] In bivariate regression model, exposure variable for each model is Age of Ego or Sexual attraction of Ego or SES of Ego or Number of friends in the network or Boyfriend/girlfriend in the network or Family member in the network and outcome is vaginal sexual activity status of Ego at baseline. In multivariate regression model 1, exposure variable is number of friends in the network, outcome variable is vaginal sexual activity status of Ego, and Ag of Ego, Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 2, exposure variable is boyfriend/girlfriend in the network, outcome variable is vaginal sexual activity status of Ego at baseline, and Age of Ego, Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 3, exposure variable is family member in the network, outcome variable is vaginal sexual activity status of Ego at baseline, and Age of Ego, Sexual attraction of Ego, and SES of Ego are controlled.

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Yes	**6.5 (2.47, 17.08) *** **		**9.02 (2.72, 30) *** **	
Family member in the network				
No				
Yes	1.81 (0.75, 4.35)			1.44 (0.58, 3.71)

*p < 0.05, **p < 0.01, ***p < 0.001

Anal sex status at baseline survey in the logistic regression models

There were two categories of anal sex status: 1) anal sex non-active (reference) and 2) anal sex active. We examined whether 1) the different kinds of people in the network 2) the different types of occupation of the people in the network and 3) different levels of closeness of alters to the respondents were associated with the change in the status of anal sex in our sample. There was no association within these exposure variables and the status of the anal sex of the adolescent apart from their sexual attraction.

The odds of being anal sexually active in those who were interested in the same sex or both sexes were 6.7 times those who were only interested in opposite sex (OR 6.72, 95% CI 1.37, 33.05, p = 0.02). This association remained significant in the multivariate logistic regression model controlling the age, and SEIFA of alters (AOR 6.91, 95% CI 1.31, 36.08, p = 0.03) (Table 4.27).

We also examined if 1) the different types of occupation of the people in the network and 2) different closeness levels of alters to the respondents were also associated with the change in the status of anal sex of adolescents in the sample, however no association was found for these variables.

Table 4-27 Bivariate and Multivariate logistic regression of anal sex status (yes/no) by the type of people in the network at baseline [17]

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	Omit	Omit	Omit	Omit
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	**6.72 (1.37, 33.05) ***	**6.91 (1.32, 36.08) ***	**6.75 (1.25, 36.5) ***	**6.93 (1.33, 36.21) ***
SES of Ego at baseline				
0 to 81.5				
Above 81.5	0.78 (0.22, 2.83)	0.75 (0.16, 3.39)	0.83 (0.20, 3.57)	0.78 (0.18, 3.33)
Number of friends in the network				
1 to 5				
6 to 10	1.59 (0.47, 5.45)	1.10 (0.24, 5.02)		
Boyfriend/girlfriend in the network				
No				
Yes	2.87 (0.78, 10.28)		3.06 (0.71, 13.27)	
Family member in the network				
No				
Yes	1 (0.29, 3.40)			0.96 (0.22, 4.11)

*p < 0.05, **p < 0.01, ***p < 0.001

[17] In bivariate regression model, exposure variable for each model is Age of Ego or Sexual attraction of Ego or SES of Ego or Number of friends in the network or Boyfriend/girlfriend in the network or Family member in the network and outcome is anal sex status of Ego at baseline. In multivariate regression model 1, exposure variable is number of friends in the network, outcome variable is anal sex status of Ego at baseline, and Ag of Ego, Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 2, exposure variable is boyfriend/girlfriend in the network, outcome variable is anal sex status of Ego at baseline, and Age of Ego, Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 3, exposure variable is family member in the network, outcome variable is anal sex status of Ego at baseline, and Age of Ego, Sexual attraction of Ego, and SES of Ego are controlled.

Number of sexual partners at baseline survey in the logistic regression models

There were two categories of the number of sexual partners: 1) one partner in the last six months (reference) and 2) more than one partner in the last six months. We examined whether 1) different kinds of people in the network 2) different types of occupation of the people in the network and 3) different closeness levels of alters to the respondents were associated with the change in the number of partners in our sample.

There were two categories of the number of high school students in the network of adolescents, 1) one to five high school students in the network (reference) and 2) more than five high school students in the network.

The odds of having multiple sexual partners in the last six months in those who had more than five high school students in the networks were 0.24 times those who had less than five high school students in the networks (OR- 0.24, 95% CI 0.06, 0.95, p= 0.04) in bivariate logistic regression. This association remained in multivariate logistic regression (AOR-0.25 0.06, 1.10, p= 0.067) after controlling for age, sexual attraction and SES (Table- 4.28).

We also examined if 1) different types of the people in the network and 2) different closeness levels of alters to the respondents were also associated with the change in the number of sexual partners in the sample, however no association was found for these variables.

Table 4-28 Bivariate and Multivariate logistic regression of number of sexual partners by the occupation of people in the network at baseline [18]

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	0.45 (0.09, 2.36)	0.42 (0.07, 2.49)	0.27 (0.04, 1.81)	0.39 (0.07, 2.26)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	1.82 (0.49, 6.68)	1 (0.22, 4.40)	1.58 (0.33, 7.51)	1.04 (0.24, 4.44)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	0.75 (0.19, 2.92)	0.95 (0.21, 4.3)	0.68 (0.16, 2.84)	0.91 (0.21, 4)
High school student				
1 to 4				
More than 4	**0.24 (0.06, 0.95)** *	0.25 (0.54, 1.13)		
University student				
No				
1 to more than 1	2.20 (0.57, 8.56)		2.65 (0.45, 15.62)	

[18] In bivariate regression model, exposure variable for each model is Age of Ego or Sexual attraction of Ego or SES of Ego or number of high school students in the network or number of university student in the network or number non-student worker in the network and outcome is number of sexual partners at baseline. In multivariate regression model 1, exposure variable is number of high school students in the network, outcome variable is number of sexual partners at baseline, and Ag of Ego, Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 2, exposure variable is number of university students in the network, outcome variable is number of sexual partners at baseline, and Age of Ego, Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 3, exposure variable is number of non-student worker in the network, outcome variable is anal number of sexual partners at baseline, and Age of Ego, Sexual attraction of Ego, and SES of Ego are controlled.

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Non-student (Worker)				
0				
1 to more than 1	2.4 (0.63, 9.14)			2.77 (0.61, 12.58)

*p < 0.05, **p < 0.01, ***p < 0.001

Age of first vaginal sex at the baseline survey in the logistic regression models

There were two categories of the age of first vaginal sex 1) 16 years and less (reference) and 2) greater than 16 years. We examined whether 1) the different kinds of the people in the network, 2) the different types of occupation of the people in the network and 3) different closeness levels of people in the network to the respondents were associated with the change in the age of first vaginal sex. In the multivariate logistic regression, age was not included in the model because age and the age of the first vaginal sex had collinearity.

In terms of the kinds of people in the networks, we investigated if the number of friends in the network, having boy/girl friends in the network, and having family members in the network were associated with the age of first vaginal sex. Neither having a boyfriend / girlfriend in the network nor family members in the network was found to be associated with the age of the first vaginal sex.

The number of friends in the network was significantly associated with the age of the first vaginal sex. Number of friends in the network was classified into two: 1) five or less than five friends in the networks and 2) more than five friends in the networks. The odds of having first sex at a later age (after 16 years) in those who had more than five friends in the networks were 6.6 times those who had five or less than five friends in the networks (AOR 6.6, 9% CI 1.18, 36.72, p= 0.035) in the multiple logistic regression after controlling sexual attraction and SES (Table 4.29).

Table 4-29 Bivariate and Multivariate logistic regression of age of first vaginal sex by the type of people in the network at baseline [19]

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	0.4 (0.10, 1.53)	0.32 (0.06, 1.66)	0.41 (0.09, 1.88)	0.33 (0.07, 1.51)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	3.44 (0.79, 15.02)	2.31 (0.43, 12.36)	2.57 (0.54, 12.36)	3.28 (0.69, 15.57)
Number of friends in the network				
1 to 5				
6 to 10	4.22 (0.98, 18.12)	**6.6 (1.18, 36.72)***		
Boyfriend/girlfriend in the network				
No				
Yes	0.3 (0.07, 1.29)		1.1 (0.22, 5.57)	
Family member in the network				
No				

[19] In bivariate regression model, exposure variable for each model is Age of Ego or Sexual attraction of Ego or SES of Ego or Number of friends in the network or Boyfriend/girlfriend in the network or Family member in the network and outcome is age of first vaginal sex at baseline. In multivariate regression model 1, exposure variable is number of friends in the network, outcome variable age of first vaginal sex, and Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 2, exposure variable is boyfriend/girlfriend in the network, outcome variable is age of first vaginal sex, and Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 3, exposure variable is family member in the network, outcome variable is age of first vaginal sex, and Sexual attraction of Ego, and SES of Ego are controlled.

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Yes	0.66 (0.17, 2.49)			0.37 (0.08, 1.77)

*p < 0.05, **p < 0.01, ***p < 0.001

In terms of the occupation of the people in the network, three exposure variables: 1) number of high school students, 2) number of university students and 3) number of nonstudents were investigated if these were associated with the age of first vaginal sex.

There were two categories of high school students: 1) 1-5 high school students in the network (reference) and 2) more than five high school students in the network. The odds of having first vaginal sex after 16 years old in those who had more than five high school students in the networks were 5.57 times those who had five or fewer students in the networks (OR 5.57, 95% CI 1.3, 23.93, p= 0.02) in the binary logistic regression. That association remained significant in the multiple logistic regression controlling sexual attraction and SES (AOR 7.9, 95% CI 1.41, 44.71, p= 0.01).

There were two categories of university students: 1) no university students in the network (reference) and 2) one and more university students in the network. The odds of having first vaginal sex after 16 years old in those who had one or more university students in the networks were 12 times those who had no university student in the networks (OR 12.14, 95% CI 2.09, 70.22, p= 0.005) in the binary logistic regression. That association remained significant in multiple logistic regression controlling sexual attraction and SES (AOR 9.5, 95% CI 1.32, 68.35, p= 0.03).

There were two categories of nonstudents worker in the network 1) no non-student in the networks and 2) one or more than one non-student in the networks. The odds of having first vaginal sex after 16 years old in those who had one or more than one non-student worker in the networks were 0.14 times those of who did not have non-student worker in the networks (AOR- 0.14, 95% CI 0.03, .64, p= 0.01). This association remained significant in the multiple logistic regression controlling sexual attraction and SES (AOR 0.6, 95% CI 0.008, 0.40, p= 0.04) (Table 4.30).

Table 4-30 Bivariate and multivariate logistic regression of age of first vaginal sex by the occupation of people in the network at baseline

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	0.4 (0.10, 1.53)	0.30 (0.05, 1.64)	0.75 (0.13, 4.39)	0.27 (0.04, 1.77)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	3.44 (0.79, 15.02)	2.70 (0.5, 14.73)	2.76 (0.51, 15)	3.99 (0.57, 27.90)
High school student				
1 to 4				
More than 4	**5.57 (1.3, 23.93)***	**7.9 (1.41, 44.71)***		
University student				
No				
1 to more than 1	**12.14 (2.09, 70.22)***		**9.5 (1.32, 68.35)***	
Non-student (Worker)				
0				
1 to more than 1	**0.14 (0.03, 0.64)***			**0.06 (0.008, 0.40)****

*p < 0.05, **p < 0.01, ***p < 0.001

For the closeness with people in the network, three variables: 1) the number of very close people, 2) the number of close people, and 3) the number of not really close people were taken as exposures for the association with age of first vaginal sex. Among these variables, the number of very close people and the number of close people were associated with the age of first vaginal sex in adolescents.

There were two categories of very close people in the network: 1) less than three very close people in the network and 2) three or more than three very close people in the network. The odds of having first sex after 16 years old in those who had three or more very close people in their networks were 6.9 times those who had less than three very close people in the networks (AOR 6.9, 95% CI 1.03, 45.83, p = 0.045) in the multivariate logistic regression model after controlling SES and sexual attraction.

There were two categories of close people in the network: 1) less than three close people in the network and 2) three or more than three close people in the network. The odds of having first sex after 16 years old in those who had three or more close people in their networks were 4.1 times those who had less than three very close people in the networks (OR 4.1, 95% CI 1.02, 16.67, p = 0.048) (Table 4.31).

Table 4-31 Bivariate and multivariate logistic regression of age of first vaginal sex by the closeness of alters to the participant in the network at baseline

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others		0.54 (0.11, 2.71)	0.44 (0.92, 2.14)	0.35 (0.08, 1.56)
SES of Ego at baseline				
0 to 81.5				
Above 81.5		4.79 (0.80, 28.51)	2.49 (0.5, 12.44)	3.16 (0.69, 14.46)
Number of very close people in the network				
less than 3				
equal or more than 3	4.23 (0.98, 18.12)	**6.9 (1.03, 45.83) ***		
Number of close people in the network				
equal or less than 3				
more than 3	**6.9 (1.03, 45.83)***		3.95 (0.08, 19.38)	
Number of not really close people in the network				
Zero				
1 and above	1.53 (0.37, 6.35)			1.13 (0.23, 5.69)

*p < 0.05, **p < 0.01, ***p < 0.001

Experience of unwanted sex at the baseline survey in the logistic regression models

We examined if 1) the different kinds of the people in the network, 2) the different types of occupation of the people in the network and 3) different closeness levels of people in the network to the respondents are associated with the experience of unwanted sex of adolescents, however no association was found for these variables.

Sex without condom at the baseline survey in the logistic regression models

There were two categories of sex without condom: 1) sex with condom (reference) and 2) sex with no condom. We examined whether 1) the different kinds of people in the networks 2) the different types of occupation of the people in the networks and 3) different levels of closeness of alters to the respondents were associated with the behaviour of sex with no condom.

The association was found between 1) having boy/girl friends in the network and the experience of sex without a condom. There were two categories of having boy/girl friends in the network 1) no boyfriend/girlfriend in the network 2) having boy/girlfriend in the network.

The odds of having sex without a condom in those who had boy/girlfriend in the networks were 11.5 times those who did not have boyfriend/girlfriend in the networks (OR 11.5, 95% CI 2.54, 52.05, p= 0.002) in the binary logistic regression. This association remained significant in the multiple logistic regression that controlled the SEIFA and sexual attraction (AOR 34.07, 95% CI 2.59, 448.88, p= 0.07) (Table 4.32).

Table 4-32 Bivariate and multivariate logistic regression of experience of sex with no condom by the type of people in the network at baseline[20]

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	0.31 (0.03, 2.98)	0.21 (0.01, 3.13)	1.45 (0.08, 26.57)	0.25 (0.02, 3.39)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	**4 (1.05, 12.26)***	2.47 (0.50, 12.16)	1.10 (0.13, 9.41)	2.26 (0.43, 11.7)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	**0.10 (0.02, 0.57) ****	**0.10 (0.01, 0.64)***	**0.05 (0.004, 0.71)***	**0.1 (0.15, 0.6) ***
Number of friends in the network				
1 to 5				
6 to 10	0.48 (0.13, 1.78)	1.35 (0.23, 8.01)		
Boyfriend/girlfriend in the network				
No				
Yes	**11.5 (2.54, 52.05) ****		**34.07 (2.59, 448.88) ****	

[20] In bivariate regression model, exposure variable for each model is Age of Ego or Sexual attraction of Ego or SES of Ego or Number of friends in the network or Boyfriend/girlfriend in the network or Family member in the network and outcome is experience of sex with no condom at baseline. In multivariate regression model 1, exposure variable is number of friends in the network, outcome variable is experience of sex with no condom at baseline, and Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 2, exposure variable is boyfriend/girlfriend in the network, outcome variable is experience of sex with no condom at baseline, and Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 3, exposure variable is family member in the network, outcome variable is experience of sex with no condom at baseline, and Sexual attraction of Ego, and SES of Ego are controlled.

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Family member in the network				
No				
Yes	1.94 (0.54, 7)			2.70 (0.51, 14.34)

*p < 0.05, **p < 0.01, ***p < 0.001

The association was found between having “not really close” people in the network and the experience of sex without a condom. There were two categories of having “not really close” people in the network 1) no “not really close” people in the networks 2) having one or more “not really close” people in the networks. The odds of having sex without condom in those who had one or more “not really close” people in the networks were 0.25 times those who did not have “not really close” people in the networks (OR 0.25, 95% CI 0.06, 0.97, p= 0.046) in the binary logistic regression (Table 4.33).

Regarding the socio-economic status of the respondents, the odds of having sex without a condom in those with higher socio-economic status (SES score greater than 81.5) were 0.10 time those with lower socio-economic status (OR= 0.10, 95% CI 0.02, 0.57, p=0.009). This association remained significant in the multiple logistic regression model that controlled sexual attraction and the number of friends in the networks (AOR= 0.11, 95% CI 0.15, 0.6, p = 0.01)

We also examined whether 1) the different kinds of occupation of the people in the network were associated with sex with no condom of adolescents in the sample; however, null association was found for these variables.

Table 4-33 Bivariate and multivariate logistic regression of experience of sex with no condom by the type of people in the network at baseline

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17		0.24 (0.02, 2.97)	0.11 (0.01, 2.42)	0.41 (0.03, 5.05)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others		2.77 (0.49, 15.6)	3.47 (0.6, 20.06)	2.35 (0.44, 12.62)
SES of Ego at baseline				
0 to 81.5				
Above 81.5		**0.11 (0.02, 0.65) ***	**0.07 (0.01, 0.56) ***	**0.09 (0.01, 0.63) ***
Number of very close people in the network				
less than 3				
equal or more than 3	1.18 (0.31, 4.44)	1.43 (0.23, 9.04)		
Number of close people in the network				
equal or less than 3				
more than 3	0.39 (0.11, 1.43)		3.02 (0.37, 24.60)	
Number of not really close people in the network				
Zero				
1 and above	**0.25 (0.06, 0.97)***			0.18 (0.03, 1.15)

*p < 0.05, **p < 0.01, ***p < 0.001

Summary of baseline analysis for the association between alter's variables and sexual behaviours of participants

Summary findings from the baseline data analysis of the association between alters' variables of the participants and their sexual behaviours variables are:

- The odds of being active in vaginal sex increased 6.5 times (OR 6.5, 95% CI 2.47, 17.08, p = 0.00) in those who had boy/girl friends on the network than those who did not.
- The odds of being anal sexually active in those who were interested in the same sex or both sexes were 6.7 times those who were only interested in opposite sex (OR 6.72, 95% CI 1.37, 33.05, p = 0.02).
- The odds of having first sex at a later age (after 16 years) in those who had more than five friends in the networks were 6.6 times those who had five or less than five friends in the networks (AOR 6.6, 9% CI 1.18, 36.72, p= 0.035).
- The odds of having sex without a condom in those who had boy/girlfriend in the networks were 11.5 times those who did not have boyfriend/girlfriend in the networks (OR 11.5, 95% CI 2.54, 52.05, p= 0.002).

Study 8: Midline analysis of alter's variables and sexual behaviours of the participants

In the midline analysis, multiple logistic regression models predict the association between alters' variables (exposure variables) and sexual behaviour variables (outcome variables) at midline survey controlling the potential confounders age, sex, sexual attraction, and SEIFA.

Type of sexual partners between the baseline survey and the midline survey in the logistic regression models

There were two categories of sexual partners: 1) regular partners and 2) regular or casual partners. We examined whether 1) the different kinds of people in the network 2) the different types of occupation of the people in the network and 3) different levels of closeness of alters to the respondents were associated with the type of sexual partners between the baseline and midline survey.

There was a significant association between the type of occupation of the people in the network and the type of sexual partners, while the other two exposure variables did not. For the variable of having university students in the network, we categorized 1) no university student in the networks and 2) one or more university students in the networks.

The odds of having regular or casual partners in those who had one or more university students in the networks were 6.11 times those who had no university student in the networks (OR= 6.11, 95% CI 1.59, 23.57, p= 0.009). This association remained significant in the multiple logistic regression that adjusted age, sexual attraction and SES (AOR 7.09, 95% CI 1.38, 36.48, p= 0.019) (Table 4.34).

The odds of having regular or casual partners in those who were from higher socioeconomic status were 5.85 times those who were from lower socioeconomic status (OR- 5.85, 95% CI 1.5, 22.8, $p < 0.05$) in binary logistic regression. This association remained significant in the multiple logistic regression (AOR= 4.35, 95% CI 1.04, 18.12, $p < 0.05$).

We also examined if 1) different kinds of people in the network and 2) different levels of closeness of people in the network were associated with sex with no condom of adolescents in the sample, however, no association was found for these variables.

Table 4-34 Bivariate and multivariate logistic regression of type of sexual partners by the occupation of people in the network between baseline and midline survey[21]

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	1.06 (0.26, 4.41)	0.9 (0.15, 5.3)	0.72 (0.12, 4.52)	0.96 (0.16, 5.7)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	0.69 (0.22, 2.18)	0.51 (0.12, 2.12)	0.39 (0.08, 1.91)	0.58 (0.14, 2.44)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	**5.85 (1.5, 22.8)***	**4.35 (1.04, 18.12)***	2.60 (0.54, 12.63)	**4.9 (1.12, 21.67)***
High school student				
1 to 4				
More than 4	1.05 (0.30, 3.62)	0.82 (0.19, 3.55)		

[21] In bivariate regression model, exposure variable for each model is Age of Ego or Sexual attraction of Ego or SES of Ego or number of high school students in the network or number of university student in the network or number non-student worker in the network and outcome is type of sexual partners by the occupation of people in the network between baseline and midline survey. In multivariate regression model 1, exposure variable is number of high school students in the network, outcome variable is type of sexual partners between baseline and midline survey, and Ag of Ego, Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 2, exposure variable is number of university students in the network, outcome variable is type of sexual partners between baseline and midline survey, and Age of Ego, Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 3, exposure variable is number of non-student worker in the network, outcome variable is type of sexual partners between baseline and midline survey, and Age of Ego, Sexual attraction of Ego, and SES of Ego are controlled.

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
University student				
No				
1 to more than 1	**6.11 (1.59, 23.57)****		**7.09 (1.38, 36.48)***	
Non-student (Worker)				
0				
1 to more than 1	0.49 (0.13, 1.78)			0.42 (0.09, 1.97)

*p < 0.05, **p < 0.01, ***p < 0.001

Vaginal sex status between the baseline survey and the midline survey in the logistic regression models

There were two categories of vaginal sex between baseline and midline: 1) vaginal sex not active and 2) vaginal sex active. We examined whether 1) the different kinds of people in the networks 2) different types of occupation of the people in the networks and 3) different closeness levels of alters to the respondents were associated with the vaginal sex status of the adolescents in the survey. There was no association between these independent predictor variables and the vaginal sex status of the adolescents.

Average episodes of sex with a condom per fortnight between the baseline survey and the midline survey in the logistic regression models

There were two categories of average episodes of sex with a condom per fortnight between baseline and midline: 1) no episode of sex with a condom and 2) one and more episodes of sex with a condom. We examined whether 1) the different kinds of people in the network 2) the different types of occupation of the people in the network and 3) different closeness levels of alters to the respondents were associated with the average episodes of sex with a condom per fortnight between baseline and midline survey of the adolescents in our sample. There was no association between these independent predictor variables and average episodes of sex with a condom per fortnight of adolescents between baseline and midline survey.

How much the participants wanted sex per fortnight (score) per fortnight between the baseline survey and the midline survey in the logistic regression models

There were two categories of how much the participants wanted sex per fortnight (score) between baseline and midline: 1) less than 85 and 2) 85 and above. We examined whether 1) different kinds of people in the networks 2) different types of occupation of the people in the networks and 3) different closeness levels of alters to the respondents were associated with how much the participants wanted sex per fortnight (score) per fortnight between the baseline and midline survey of the adolescents in our sample. There was no association between these independent predictor variables and the score of how much the participants wanted sex per fortnight.

How much the participant enjoyed sex per fortnight (score) between the baseline survey and the midline survey in the logistic regression models

There were two categories of average how much the participant enjoyed sex per fortnight (score) between baseline and midline: 1) less than 75 and 2) 75 and above. We examined whether 1) different kinds of people in the network 2) different types of occupation of the people in the network and 3) different closeness levels of alters to the respondents were associated with the average how much the participant enjoyed sex per fortnight (score) between baseline and midline survey of the adolescents. Significant association was found between different kinds of people in the networks and the average score of enjoying sex of adolescents per fortnight between baseline and midline survey.

Regarding the different kinds of relationship with the people in the network, we examined whether 1) the number of friends in the networks 2) having boy/girlfriend in the networks and 3) having family member in the networks would be associated with the average score of enjoying sex of adolescents per fortnight between baseline and midline. Significant association was found between the number of friends in the networks and the score of enjoying sex of adolescents. We categorized the number of friends in the networks as 1) 1-5 friends in the networks and 2) more than five friends in the networks. The odds of having higher score of enjoying sex per fortnight in adolescents who had more than five friends in the networks were 0.22 times those who had 1-5 friends in the networks AOR= 0.22, 95% CI 0.06, 0.81, p = 0.02) in multiple logistic regression (Table 4.35).

Table 4-35 Bivariate and multivariate logistic regression of how much the participant enjoyed sex per fortnight (score) by the type of people in the network between baseline and midline survey [22]

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	2.08 (0.61, 7.13)	1.17 (0.27, 5.05)	1.03 (0.25, 4.23)	1.09 (0.27, 4.37)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	1.44 (0.54, 3.81)	1.22 (0.36, 4.16)	1.27 (0.39, 4.15)	1.36 (0.42, 4.40)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	0.8 (0.29, 2.24)	0.56 (0.17, 1.89)	0.65 (0.20, 2.08)	0.61 (0.19, 1.95)
Number of friends in the network				

[22] In bivariate regression model, exposure variable for each model is Age of Ego or Sexual attraction of Ego or SES of Ego or Number of friends in the network or Boyfriend/girlfriend in the network or Family member in the network and outcome how much the participant enjoyed sex per fortnight (score) between baseline and midline survey. In multivariate regression model 1, exposure variable is number of friends in the network, outcome variable is how much the participant enjoyed sex per fortnight (score) between baseline and midline survey, and Ag of Ego, Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 2, exposure variable is boyfriend/girlfriend in the network, outcome variable is how much the participant enjoyed sex per fortnight (score) between baseline and midline survey, and Age of Ego, Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 3, exposure variable is family member in the network, outcome variable is how much the participant enjoyed sex per fortnight (score) between baseline and midline survey, and Age of Ego, Sexual attraction of Ego, and SES of Ego are controlled.

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
1 to 5				
More than 5	0.04 (0.13, 1.30) p= 0.13	**0.22 (0.06, 0.81)***		
Boyfriend/girlfriend in the network				
No				
Yes	2.39 (0.82, 7.00)		2.71 (0.83, 8.85)	
Family member in the network				
No				
Yes	0.91 (0.32, 2.61)			1.35 (0.43, 4.28)

*p < 0.05, **p < 0.01, ***p < 0.001

Number of sexual partners per fortnight between the baseline survey and the midline survey in the logistic regression models

There were two categories of average number of sexual partners per fortnight between baseline and midline: 1) one partner and 2) more than one partner. We examined whether 1) the different kinds of relationship with the people in the networks 2) the different types of occupation of the people in the networks and 3) different levels of alters to the respondents were associated with the average number of sexual partners per fortnight between baseline and midline survey of the adolescents. Significant association was found between different kinds of people in the networks and the average number of sexual partners per fortnight between the baseline and midline survey.

Regarding the different kinds of relationship with people in the networks between baseline and midline, we focused on whether 1) the number of people in the networks 2) having boy/girlfriend and 3) having family members in the networks influences the average number of sexual partners per fortnight between baseline and end line survey.

The odds of having more than one partner in those who had boy/girlfriend in the networks were 3.55 times those who had no boy/girlfriend in the networks (OR 3.8, 95% CI 1.32, 10.9, p= 0.01). This association remained significant in the multivariate model, which adjusted age, sexual attraction and SEIFA11 (AOR- 3.55, 1.16, 10.87, p= 0.027) (Table 4.36).

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Table 4-36 Bivariate and multivariate logistic regression of average number of sexual partners per fortnight by the type of people in the network between baseline and midline survey[23]

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	0.45 (0.16, 1.25)	1.26 (0.34, 4.66)	1.11 (0.29, 4.24)	1.19 (0.33, 4.32)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others		1.29 (0.42, 3.91)	1.29 (0.41, 4.04)	1.4 (0.46, 4.21)
SES of Ego at baseline				
0 to 81.5				
Above 81.5		0.66 (0.22, 1.98)	0.72 (0.23, 2.22)	0.66 (0.22, 1.96)
Number of friends in the network				
1 to 5				
6 to 10	0.45 (0.16, 1.25)	0.42 (0.14, 1.27)		
Boyfriend/girlfriend in the network	**3.8 (1.32, 10.9)* p=0.013**		**3.55 (1.16, 10.87)* p= 0.027**	

[23] In bivariate regression model, exposure variable for each model is Age of Ego or Sexual attraction of Ego or SES of Ego or Number of friends in the network or Boyfriend/girlfriend in the network or Family member in the network and outcome is vaginal sexual activity status of Ego at baseline. In multivariate regression model 1, exposure variable is number of friends in the network, outcome variable is vaginal sexual activity status of Ego, and Ag of Ego, Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 2, exposure variable is boyfriend/girlfriend in the network, outcome variable is vaginal sexual activity status of Ego at baseline, and Age of Ego, Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 3, exposure variable is family member in the network, outcome variable is vaginal sexual activity status of Ego at baseline, and Age of Ego, Sexual attraction of Ego, and SES of Ego are controlled.

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
No				
Yes				
Family member in the network				
No				
Yes	1.65 (0.60, 4.52)			1.56 (0.53, 4.65)

*p < 0.05, **p < 0.01, ***p < 0.001

Summary of midline analysis for the association between alter's variables and sexual behaviours of participants

Summary findings from the midline data analysis of the association between alters' variables of the participants and their sexual behaviours variables are:

- The odds of having regular or casual partners in those who had one or more university students in the networks were 6.11 times those who had no university student in the networks (OR= 6.11, 95% CI 1.59, 23.57, p= 0.009).
- The odds of having higher score of enjoying sex per fortnight in adolescents who had more than five friends in the networks were 0.22 times those who had 1-5 friends in the networks AOR= 0.22, 95% CI 0.06, 0.81, p = 0.02).
- The odds of having more than one partner in those who had boy/girlfriend in the networks were 3.55 times those who had no boy/girlfriend in the networks (OR 3.8, 95% CI 1.32, 10.9, p= 0.01).

Study 9: End line analysis of alter's variables and sexual behaviours of the participants

In the end line analysis, multiple logistic regression models predict the association between alters' variables (exposure variables) and sexual behaviour variables (outcome variables) at end line survey controlling the potential confounders age, sex, sexual attraction, and SEIFA.

Type of sexual partners between midline and end line surveys in the logistic regression models

There were two categories of type of sexual partner per fortnight between the midline and end line: 1) regular partner and 2) regular or casual partner.

We investigated whether 1) the different kinds of relationship with the people in the networks 2) the different types of occupation of the people in the networks and 3) different levels of closeness of alters to the respondents were associated with the type of sexual partners between the midline and end line survey of adolescents. Significant association was found between 1) different kinds of relationship with the people in the networks and type of sexual partners; and 2) different types of occupation of the people in the networks and type of sexual partner between midline and end line.

To test the association between different kinds of people in the networks and type of sexual partners between midline and end line survey; we tested three independent variables: 1) number of friends in the networks 2) having boy/girlfriend in the networks and 2) having family members in the networks. In particular, the number of friends in the networks between the midline and end line survey was categorized into two 1) 1-5 friends in the networks and 2) more than five friends in the networks.

The odds of having formal or casual partners in those who had more than five friends in the networks were 0.21 times those who had 1-5 friends in the networks (OR 0.21, 95% CI 0.06, 0.81, p= 0.02) in bivariate logistic regression. This association remained significant in multivariate logistic regression as well (AOR 0.21, 95% CI 0.43, 0.99, p= 0.049).

There were two categories of having boy/girl friends in the network 1) no boy/girlfriend in the network and 2) having boy/girl friends in the network. The odds of having formal or casual partners in those who had a boy/girlfriend in the networks were 0.23 times those who did not have boy/girlfriend in the networks (OR 0.23, 0.06, 0.88, p = 0.03) in bivariate logistic regression and this association remained significant (AOR 0.17, 95% CI 0.03, 0.84, p= 0.03) in multiple logistic regression which adjusted age, sexual attraction, and SES (Table 4.37).

Table 4-37 Bivariate and multivariate logistic regression of type of sexual partners by the type of people in the network between midline and end line survey[24]

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	2 (0.58, 6.86)	3.29 (0.63, 17.17)	2.85 (0.53, 15.23)	2 (0.45, 8.88)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	0.74 (0.25, 2.17)	1.15 (0.3, 4.57)	0.87 (0.22, 3.54)	1.06 (0.29, 3.92)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	1.73 (0.55, 5.47)	2.52 (0.62, 10.21)	2.13 (0.53, 8.61)	2.05 (0.56, 7.53)
Number of friends in the network				
1 to 5				
6 to 10	**0.21 (0.06, 0.81)***	**0.21 (0.43, 0.99)***		
Boyfriend/girlfriend in the network				
No				

[24] In bivariate regression model, exposure variable for each model is Age of Ego or Sexual attraction of Ego or SES of Ego or Number of friends in the network or Boyfriend/girlfriend in the network or Family member in the network and outcome is type of sexual partners between midline and end line survey. In multivariate regression model 1, exposure variable is number of friends in the network, outcome variable is type of sexual partners between midline and end line survey, and Ag of Ego, Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 2, exposure variable is boyfriend/girlfriend in the network, outcome variable is type of sexual partners between midline and end line survey, and Age of Ego, Sexual attraction of Ego, and SES of Ego are controlled. In multivariate regression model 3, exposure variable is family member in the network, outcome variable is type of sexual partners between midline and end line survey, and Age of Ego, Sexual attraction of Ego, and SES of Ego are controlled.

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Yes	**0.23 (0.06, 0.88)***		**0.17 (0.03, 0.84)***	
Family member in the network				
No				
Yes	1.44 (0.43, 4.77)			1.18 (0.32, 4.36)

*p < 0.05, **p < 0.01, ***p < 0.001

To validate the association between people with different types of occupation in the network and type of sexual partners between midline and end line survey; we tested three independent variables: 1) number of high school students in the network 2) having university students in the network and 2) having non-student (worker) in the network. An association was found between the having university students in the network and the type of sexual partners of adolescents between the midline and the end line survey. We categorized having university students in the network category as 1) no university students in the network and 2) 1 or more university students in the network. Adolescents who had university students in the network were more likely to have regular or casual partners than those who did not have (OR 5.78, 95% CI 1.52, 21.93, p= 0.01) in the bivariate analysis and (OR 21.47, 95%CI 1.86, 248.99, p= 0.014) in the multivariate analysis controlling age, sexual attraction and SES) (Table 4.38).

We also investigated if 1) different closeness levels of alters to the respondents were associated with the type of sexual partners between midline and end line survey of adolescents. The null association was found between all of this variable and the type of sexual partners between midline and end line survey.

Table 4-38 Bivariate and multivariate logistic regression of type of sexual partners by the occupation of people in the network between midline and end line survey[25]

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	2 (0.58, 6.86)	2.09 (0.42, 10.55)	0.19 (0.01, 2.48)	2.01 (0.45, 9)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	0.74 (0.25, 2.17)	1.04 (0.28, 3.83)	0.51 (0.11, 2.41)	1.08 (0.28, 4.13)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	1.73 (0.55, 5.47)	2.02 (0.54, 7.50)	1.39 (0.32, 6.11)	2.00 (0.53, 7.62)
High school student				
1 to 4				
More than 4	0.8 (0.24, 2.68)	1.13 (0.23, 4.76)		
University student				
No				

[25] In bivariate regression model, exposure variable for each model is age of ego or sexual attraction of ego or SES of ego or number of high school students in the network or number of university student in the network or number non-student worker in the network and outcome is type of sexual partners between midline and end line survey. In multivariate regression model 1, exposure variable is number of high school students in the network, outcome variable is type of sexual partners between midline and end line survey, and age of ego, sexual attraction of ego, and SES of ego are controlled. In multivariate regression model 2, exposure variable is number of university students in the network, outcome variable is type of sexual partners between midline and end line survey, and age of ego, sexual attraction of ego, and SES of ego are controlled. In multivariate regression model 3, exposure variable is number of non-student (worker) in the network, outcome variable is type of sexual partners between midline and end line survey, and age of ego, sexual attraction of ego, and SES of ego are controlled.

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
1 to more than 1	**5.78 (1.52, 21.93)***		**21.47 (1.86, 248.99)***	
Non-student (Worker)				
0				
1 to more than 1	0.65 (0.11, 4)			0.86 (0.12, 6.26)

*p < 0.05, **p < 0.01, ***p < 0.001

Vaginal sex status between the midline survey and the end line survey in the logistic regression models

There were two categories of vaginal sex status of adolescents between midline and end line: 1) vaginal sex status active and 2) vaginal sex status nonactive.

We investigated whether 1) the different kinds of people in the network 2) the different types of occupation of the people in the network and 3) different levels of closeness of alters to the respondents were associated with the status of the vaginal sex of adolescents between the midline and end line survey of adolescents. Significant association was found between 1) different levels of closeness of alters to the respondents and the status of vaginal sex of adolescents.

In terms of the different levels of closeness of alters to the respondents; we tested three independent variables 1) the number of very close people 2) the number of close people and 3) the number of people who were not close at all with the outcome variable the status of vaginal sex of adolescents. The number of very close people in the networks was associated with the status of the vaginal sex of adolescents. There were two categories of the number of very close people in the network: 1) less than three and 2) three and above.

The odds of having active vaginal status in those who had three or more very close people in the networks were 0.01 times those who had less than three very close people in the networks (AOR 0.01, 95% CI 0.00006, 0.81, p= 0.04) (Table 4.39).

Table 4-39 Bivariate and multivariate logistic regression of status of vaginal sex by the closeness of alters to the participant in the network between midline and end line survey[26]

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	**1.03 (0.24, 4.49) ***	14.95 (0.49, 460.03)	1.83 (0.23, 14.61)	1.84 (0.22, 15.32)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	1.05 (0.29, 3.74)	0.1 (0.01, 1.64)	0.7 (0.12, 4.18)	0.94 (0.15, 6.07)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	2.42 (0.53, 11)	34.36 (1.88, 629.51)*	9.05 (0.95, 86.58)	9 (0.93, 87.16)
Number of very close people in the network				
less than 3				
equal or more than 3	0.23 (0.04, 1.20)	**0.01 (0.00006, 0.81)***		

[26] In bivariate regression model, exposure variable for each model is age of ego or sexual attraction of ego or SES of ego or number of very close people in the network or number of close people in the network or number of not really close people in the network and outcome is status of vaginal sex between midline and end line survey. In multivariate regression model 1, exposure variable is number of very close people in the network, outcome variable is status of vaginal sex between midline and end line survey, and ag of ego, sexual attraction of ego, and SES of ego are controlled. In multivariate regression model 2, exposure variable is number of close people in the network, outcome variable is status of vaginal sex between midline and end line survey, and age of ego, sexual attraction of ego, and SES of ego are controlled. In multivariate regression model 3, exposure variable is not really close people in the network, outcome variable is status of vaginal sex between midline and end line survey, and age of ego, sexual attraction of ego, and SES of ego are controlled.

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Number of close people in the network				
equal or less than 3				
more than 3	0.66 (0.15, 2.95)		0.67 (0.1, 4.55)	
Number of not really close people in the network				
Zero				
1 and above	0.59 (0.13, 2.64)			0.2 (0.02, 2.03)

*p < 0.05, **p < 0.01, ***p < 0.001

The odds of having active vaginal sex in those who were 16-17 years of age were 1.03 times those who were 15 years of age (OR- 1.03, 95% CI0.24, 4.49, p < 0.04) in binary logistic regression.

We also examined whether 1) the different kinds of relationship of the people in the networks and 2) the different types of occupation of people in the networks were associated with the status of vaginal sex of adolescents in the sample, however, null association was found for these variables.

Anal sex status between the midline survey and the end line survey in the logistic regression models

There were two categories of anal sex status of adolescents between the midline and end line: 1) active anal sex status and 2) anal sex status non-active.

We investigated whether 1) the different kinds of relationships with the people in the network 2) the different types of occupation of the people in the network and 3) different closeness levels of alters to the respondents were associated with the status of the anal sex of adolescents between midline and end-line survey of adolescents. No association was found between all of these variables and the status of the anal sex of adolescents between the midline and endline survey.

Average episodes of sex with a condom per fortnight between the midline survey and the end line survey in the logistic regression models

There were two categories for average episodes of sex with a condom of adolescents per fortnight between the midline and the end line: 1) no episode of sex with a condom[27] and 2) one or more episodes of sex with a condom. We investigated whether 1) different kinds of relationship with the people in the network 2) different types of occupation of the people in the network and 3) different closeness levels of alters to the respondents were associated with average episodes of sex with a condom of adolescents per fortnight between midline and end line survey. Significant association was

[27] Condomless sex

found between the different kinds of occupation of the people in the network and average episodes of sex with a condom per fortnight between the midline and end line survey.

We looked at three independent variables for the different kinds of occupation of the people in the networks between middle and end line survey 1) high school students 2) university students and 3) nonstudents.

The association was found between having university students in the networks and average episodes of sex with a condom per fortnight between the middle and end of the survey. For having university students, we categorized two categories 1) no university students in the networks between midline and end-line survey and 2) one or more university students in the networks. The odds of having more episodes of sex with a condom per fortnight in those who had university students in the networks were 7.7 times those who did not have university student in the networks (OR 7.7, 95% CI 1.67, 35.51, p= 0.038) in bivariate logistic regression. This association remained significant in multiple logistic regression model that controlled age, sexual attraction and SES (AOR 10.63, 95% CI 1.14, 98.91, p= 0.03).

The odds of having more episodes of sex with condom per fortnight in those with a high socio-economic status were 3.38 times those with a lower socio-economic status (OR 3.38, 95% CI 0.95, 12.01, p= 0.059) in bivariate logistic regression. This association remained significant in multivariate logistic regression (AOR- 11.32, 95% CI 1.68, 76.10, p= 0.013) (Table 4.40).

We investigated if 1) different kinds of people in the networks and 2) different closeness levels of alters to the respondents were associated with average episodes of sex with a condom per fortnight of adolescents between midline and end line survey of adolescents. No association was found between all of these variables and average episodes of sex with a condom per fortnight of adolescents between midline and end line survey.

Table 4-40 Bivariate and multivariate logistic regression of average episodes of sex with a condom per fortnight by the occupation of people in the network between midline and end line survey[28]

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	2.25 (0.63, 8.07)	4.13 (0.57, 29.87)	0.80 (0.07, 9.05)	4.35 (0.63, 29.93)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	1 (0.31, 3.22)	1.37 (0.27, 6.93)	0.61 (0.1, 3.91)	1.70 (0.31, 9.24)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	3.38 (0.95, 12.01)	11.32 (1.68, 76.100)*	9.23 (1.33, 64.22)*	10.23 (1.56, 67.13)*
High school student				
1 to 4				
More than 4	0.86 (0.21, 3.48)	0.83 (0.15, 4.60)		

[28] In bivariate regression model, exposure variable for each model is age of ego or sexual attraction of ego or SES of ego or number of high school students in the network or number of university student in the network or number non-student worker in the network and outcome is average episodes of sex with a condom per fortnight between midline and endline survey. In multivariate regression model 1, exposure variable is number of high school students in the network, outcome variable is average episodes of sex with a condom per fortnight between midline and endline survey, and age of ego, sexual attraction of ego, and SES of ego are controlled. In multivariate regression model 2, exposure variable is number of university students in the network, outcome variable average episodes of sex with a condom per fortnight between midline and endline survey, and age of ego, sexual attraction of ego, and SES of ego are controlled. In multivariate regression model 3, exposure variable is number of non-student worker in the network, outcome variable is average episodes of sex with a condom per fortnight between midline and endline survey, and age of ego, sexual attraction of ego, and SES of ego are controlled.

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
University student				
No				
1 or more than 1	**7.70 (1.67, 35.51)****		**10.63 (1.14, 98.91)***	
Non-student (Worker)				
0				
1 to more than 1	0.4 (0.04, 3.67)			0.35 (0.03, 4.03)

*p < 0.05, **p < 0.01, ***p < 0.001

How much the participants wanted sex per fortnight (score) between the midline survey and the end line survey in the logistic regression models

There were two categories of how much the participants wanted sex per fortnight (score) between midline and end line: 1) less than 85 and 2) 85-100.

We investigated whether 1) the different kinds of people in the network 2) the different types of occupation of the people in the network and 3) the different levels of closeness of alters to the respondents were associated with how much the participants wanted sex per fortnight (score) between midline and end line survey.

Significant association was found between 1) the different kinds of people in the network and how much the participants wanted sex per fortnight (score) and 2) the different types of occupation of the people in the network and how much the participants wanted sex per fortnight (score).

To test the effect of having different kinds of relationships with the people in the network and how much the participants wanted sex per fortnight (score), we used three independent indicators 1) number of friends in the networks 2) having boy/girlfriend in the networks and 3) having family members in the networks. The association was found between having a boy / friend and girlfriend in the networks and how much the participants wanted sex per fortnight (score). We categorized having boy/girlfriend in the network as 1) no boy/girlfriend in the network and 2) having boy/girlfriend in the network.

The odds of having higher score of wanted sex in those who had boy/girlfriend in the networks were 3.63 times those who did not have boy/girlfriend in the networks (OR- 3.63, 95% CI 1.07, 12.30, p= 0.04) in bivariate logistic regression. This association remained significant in multivariate logistic regression (AOR- 4.56, 95% CI 1.12, 18.53, p= 0.034) (Table 4.41).

Table 4-41 Bivariate and multivariate logistic regression of how much the participants wanted sex per fortnight (score) by the type of people in the network between midline and end line survey [29]

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	1.22 (0.35, 4.24)	0.79 (0.17, 3.67)	0.66 (0.13, 3.26)	0.78 (0.16, 3.69)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	1.78 (0.62, 5.12)	1.62 (0.46, 5.66)	2.04 (0.53, 7.88)	1.56 (0.42, 5.70)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	0.73 (0.24, 2.21)	0.41 (0.12, 1.42)	0.40 (0.11, 1.52)	0.41 (0.11, 1.52)
Number of friends in the network				
1 to 5				
6 to 10	1.08 (0.33, 3.53)	1.03 (0.26, 4.17)		

[29] In bivariate regression model, exposure variable for each model is age of ego or sexual attraction of ego or SES of ego or number of high school students in the network or number of university student in the network or number non-student worker in the network and outcome is how much the participants wanted sex per fortnight (score) between midline and endline survey. In multivariate regression model 1, exposure variable is number of high school students in the network, outcome variable is how much the participants wanted sex per fortnight (score) between midline and endline survey between midline and endline survey, and age of ego, sexual attraction of ego, and SES of ego are controlled. In multivariate regression model 2, exposure variable is number of university students in the network, outcome variable is how much the participants wanted sex per fortnight (score) between midline and endline survey, and age of ego, sexual attraction of ego, and SES of ego are controlled. In multivariate regression model 3, exposure variable is number of non-student worker in the network, outcome variable is how much the participants wanted sex per fortnight (score) between midline and endline survey between midline and endline survey, and age of ego, sexual attraction of ego, and SES of ego are controlled.

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Boyfriend/girlfriend in the network				
No				
Yes	**3.63 (1.07, 12.30)* p= 0.038**		**4.56 (1.12, 18.53)* p= 0.034**	
Family member in the network				
No				
Yes	**0.26 (0.08, 0.86)* p=0.027**			0.29 (0.08, 1.1)

*p < 0.05, **p < 0.01, ***p < 0.001

With regards to the different occupation of people in the network, we analysed three independent variables 1) number of high school student in the network 2) having university student in the network and 3) having non-student worker in the network with the dependent variable how much the participants wanted sex per fortnight (score) between midline and end line survey. The association was found between having university students and how much the participants wanted sex per fortnight (score). We categorised the variable having university students as 1) no university student in the networks and 2) having university students in the networks.

The odds of a higher score of wanted sex per fortnight in those who had university students in the networks were 0.19 times those who had no university students in the networks (OR = 0.19, 9% CI 0.05, 0.72, p= 0.01) in bivariate logistic regression. This association remained significant in the multivariate logistic regression (AOR 0.05, 95% CI 0.004, 0.56, p= 0.02) (Table 4.42).

We investigated if 1) the different kinds of relationships with the people in the network and 2) different closeness levels of alters to the respondents were associated with how much the participants wanted sex per fortnight (score) of adolescents between midline and end line survey of adolescents. No association was found between these variables and how much the participants wanted sex per fortnight (score) of adolescents between midline and end line survey.

Table 4-42 Bivariate and multivariate logistic regression of how much the participants wanted sex per fortnight (score) by the occupation of people in the network between midline and end line survey

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	1.22 (0.35, 4.24)	0.71 (0.14, 3.55)	7.96 (0.6, 106.07)	0.76 (0.17, 3.44)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	1.78 (0.62, 5.12)	1.60 (0.46, 5.6)	3.39 (0.77, 14.83)	1.27 (0.33, 4.79)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	0.73 (0.24, 2.21)	0.42 (0.12, 1.46)	0.59 (0.15, 2.38)	0.44 (0.12, 1.54)
High school student				
1 to 4				
More than 4	0.64 (0.2, 2.04)	0.78 (0.20, 3.02)		
University student				
No				
1 to more than 1	**0.19 (0.05, 0.72)***		**0.05 (0.004, 0.56)***	
Non-student (Worker)				
0				
1 to more than 1	3 (0.54, 16.69)			2.66 (0.42, 16.97)

*p < 0.05, **p < 0.01, ***p < 0.001

How much the participant enjoyed sex per fortnight (score) between the midline survey and the end line survey in the logistic regression models

There were two categories of average how much the participant enjoyed sex per fortnight (score) between the midline and the end line: 1) less than 72 and 2) 72-100.

We investigated whether 1) the different kinds of people in the networks 2) the different types of occupation of the people in the networks and 3) the different levels of closeness of alters to the respondents were associated with the average score of enjoying sex by adolescents per fortnight between midline and end line survey. Significant associations were found between the different kinds of people in the networks.

To test the association between different kinds of relationships with people in the networks and average how much the participant enjoyed sex per fortnight (score), we analyzed three independent variables 1) number of friends in the networks 2) having boy/girlfriend in the networks and 3) having family member in the networks. The association was found between having a boy / girlfriend in the networks and the average score of enjoying sex per week in adolescents between midline and end line survey. We created the category of having a boy/girlfriend in the network as 1) no boy/girlfriend in the network and 2) having a boy/girlfriend in the network.

The odds of having higher score of enjoying sex per fortnight in those who had a boy / girlfriend in the network were 9 times those who did not have boy/girlfriend in the networks (OR- 9, 95% CI 1.67, 48.37, p= 0.01) in the bivariate logistic regression. This association remained significant in the multivariate logistic regression (AOR- 12.78, 95% CI 1.48, 110.39, p= 0.021) (Table 4.43).

We investigated if 1) the different kinds of occupation of the people in the network and 2) different closeness levels of alters to the respondents were associated with the average how much the participant enjoyed sex per fortnight (score) of adolescents between midline and end line survey of adolescents. No association was found between these variables and how much the participant enjoyed sex per fortnight (score) of adolescents between midline and end line survey.

Table 4-43 Bivariate and multivariate logistic regression of average how much the participant enjoyed sex per fortnight (score) by the type of people in the network between midline and end line survey [30]

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	2.58 (0.66, 10.03)	5.14 (0.76, 34.90)	4.64 (0.65, 32.93)	5.01 (0.76, 32.89)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	1.35 (0.39, 4.72)	3.13 (0.55, 17.77)	5.58 (0.72, 43.28)	3.54 (0.57, 21.98)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	0.54 (0.14, 2.17)	0.24 (0.04, 1.44)	0.17 (0.02, 1.36)	0.20 (0.03, 1.28)
Number of friends in the network				
1 to 5				
6 to 10	0.99 (0.24, 4.03)	0.53 (0.08, 3.49)		

[30] In bivariate regression model, exposure variable for each model is age of ego or sexual attraction of ego or SES of ego or number of high school students in the network or number of university student in the network or number non-student worker in the network and outcome is how much the participants enjoyed sex per fortnight (score) between midline and endline survey. In multivariate regression model 1, exposure variable is number of high school students in the network, outcome variable is how much the participants enjoyed sex per fortnight (score) between midline and endline survey between midline and endline survey, and age of ego, sexual attraction of ego, and SES of ego are controlled. In multivariate regression model 2, exposure variable is number of university students in the network, outcome variable is how much the participants enjoyed sex per fortnight (score) between midline and endline survey, and age of ego, sexual attraction of ego, and SES of ego are controlled. In multivariate regression model 3, exposure variable is number of non-student worker in the network, outcome variable is how much the participants enjoyed sex per fortnight (score) between midline and endline survey between midline and endline survey, and age of ego, sexual attraction of ego, and SES of ego are controlled.

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Boyfriend/girlfriend in the network				
No				
Yes	**9 (1.67, 48.37)***		**12.78 (1.48, 110.39)***	
Family member in the network				
No				
Yes	2.12 (0.54, 8.34)			3.67 (0.63, 21.36)

*p < 0.05, **p < 0.01, ***p < 0.001

Average number of sexual partners per fortnight between the midline survey and the end line survey in the logistic regression models

There were two categories of average number of sexual partners per fortnight between midline and end line: 1) one partner and 2) more than one partner.

We investigated whether 1) different kinds of people in the networks 2) different types of occupation of the people in the networks and 3) different closeness levels of alters to the respondents were associated with the average number of sexual partners per fortnights of adolescents between midline and the end line survey. Significant association was found between 1) different kinds of people in the network and the average number of sexual partners of adolescents per week and 2) different levels of closeness of changes to the respondents and the average number of sexual partners per week between the respondents and average number of sexual partners per fortnight between the midline and end line survey.

To find the effect of different relationships with people in the network, we analysed three independent variables: 1) number of friends in the networks, 2) having boy/girl friends in the network, and 3) having family members in the networks. The association was found between having boy/girlfriend in the network and the average number of sexual partners between the midline and the endline survey. We categorized the variable having a boy/girlfriend in the network as 1) no boy/girlfriend in the networks and 2) have a boy/girlfriend in the networks.

The odds of having more than one partner per fortnight in those who had a boy/girlfriend in the networks were 4.6 times those who had no boy/girlfriend in the networks (OR- 4.6, 95% CI 1.47, 14.78, p= 0.009) in the bivariate logistic regression. This association remained significant in the multivariate logistic regression (OR- 5.81, 95% CI 1.54, 21.85, p= 0.009) (Table 4.44).

For the different levels of closeness with the people in the network, we examined three variables: 1) the number of very close people in the networks, 2) the number of close people in the networks and 3) the number of “not really close” people.

Among these, the number of very close people in the network was associated with the average number of partners per fortnight of adolescents between the midline and the end line surveys. The number of very close people in the network between midline and end line survey was categorised as 1) less than 3 and 2) 3-9 very close people. The odds of having more than one partner per fortnight in those who had higher number of very close people in the networks (3-9) were 0.22 times those who had less than three very close people in the networks (OR- 0.22, 95% CI 0.07, 0.72, p= 0.01) in bivariate logistic regression. This association remained significant in the multivariate logistic regression (AOR 0.26, 95% CI 0.07, 0.93, p= 0.04) (Table 4.45).

We investigated if 1) the different types of occupation of the people in the networks was associated with the average number of sexual partners per fortnight of adolescents between midline and end line survey of adolescents. No association was found between these variables and average number of sexual partners per fortnight between midline and end line survey.

Table 4-44 Bivariate and multivariate logistic regression of average number of sexual partners per fortnight by the type of people in the network between midline and end line survey [31]

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	1.33 (0.42, 4.22)	1.26 (0.28, 5.62)	0.77 (0.16, 3.62)	0.99 (0.24, 4.07)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	1.36 (0.52, 3.57)	1.62 (0.49, 5.42)	2.09 (0.55, 7.90)	1.57 (0.48, 5.18)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	0.58 (0.21, 1.62)	0.55 (0.17, 1.81)	0.47 (0.13, 1.74)	0.56 (0.17, 1.80)
Number of friends in the network				
1 to 5				
6 to 10	0.7 (0.23, 2.13)	0.49 (0.13, 1.79)		
Boyfriend/girlfriend in the network				
No				

[31] In bivariate regression model, exposure variable for each model is age of ego or sexual attraction of ego or SES of ego or number of friends in the network or boyfriend/girlfriend in the network or family member in the network and outcome is number of sexual partners per fortnight between midline and end line survey. In multivariate regression model 1, exposure variable is number of friends in the network, outcome variable is vaginal sexual activity status of ego, and age of Ego, sexual attraction of ego, and SES of ego are controlled. In multivariate regression model 2, exposure variable is boyfriend/girlfriend in the network, outcome variable is number of sexual partners per fortnight between midline and end line survey, and age of ego, sexual attraction of ego, and SES of ego are controlled. In multivariate regression model 3, exposure variable is family member in the network, outcome variable is number of sexual partners per fortnight between midline and end line survey, and age of ego, sexual attraction of ego, and SES of ego are controlled.

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Yes	**4.6 (1.47, 14.78)****		**5.81 (1.54, 21.85)****	
Family member in the network				
No				
Yes	0.82 (0.28, 2.41)			0.99 (0.31, 3.21)

*p < 0.05, **p < 0.01, ***p < 0.001

Table 4-45 Bivariate and multivariate logistic regression of average number of sexual partners per fortnight by the closeness of alters to the participant in the network between midline and end line survey

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Age of Ego at baseline				
15				
16, 17	1.33 (0.42, 4.22)	1.41 (0.3, 6.68)	1.0 (0.24, 4.16)	0.98 (0.23, 4.10)
Sexual attraction of Ego at baseline				
Only to people of the opposite sex				
Same sex, both or others	1.36 (0.52, 3.57)	1.49 (0.42, 5.23)	1.58 (0.48, 5.22)	1.56 (0.47, 5.16)
SES of Ego at baseline				
0 to 81.5				
Above 81.5	0.58 (0.21, 1.62)	0.54 (0.16, 1.88)	0.55 (0.17, 1.79)	0.56 (0.17, 1.80)
Number of very close people in the network				
less than 3				
equal or more than 3	**0.22 (0.07, 0.72)***	**0.26 (0.07, 0.93)***		

	Model 1 Bivariate OR (95% CI)	Model 2 Multivariate AOR (95% CI)	Model 3 Multivariate AOR (95% CI)	Model 4 Multivariate AOR (95% CI)
Number of close people in the network				
equal or less than 3				
more than 3	0.65 (0.21, 1.99)		0.87 (0.26, 2.9)	
Number of not really close people in the network				
Zero				
1 and above	1.07 (0.36, 3.19)			1.08 (0.33, 3.58)

*p < 0.05, **p < 0.01, ***p < 0.001

Summary of end line analysis for the association between alter's variables and sexual behaviours of participants

Summary findings from the end line data analysis of the association between alters' variables of the participants and their sexual behaviours variables are:

- The odds of having formal or casual partners in those who had more than five friends in the networks were 0.21 times those who had 1-5 friends in the networks (OR 0.21, 95% CI 0.06, 0.81, p= 0.02).
- The odds of having formal or casual partners in those who had a boy/girlfriend in the networks were 0.23 times those who did not have boy/girlfriend in the networks (OR 0.23, 0.06, 0.88, p = 0.03).
- The odds of having more episodes of sex with a condom per fortnight in those who had university students in the networks were 7.7 times those who did not have university student in the networks (OR 7.7, 95% CI 1.67, 35.51, p= 0.038).
- The odds of having more episodes of sex with condom per fortnight in those with a high socio-economic status were 3.38 times those with a lower socio-economic status (OR 3.38, 95% CI 0.95, 12.01, p= 0.059).
- The odds of having higher score of wanted sex in those who had boy/girlfriend in the networks were 3.63 times those who did not have boy/girlfriend in the networks (OR- 3.63, 95% CI 1.07, 12.30, p= 0.04).
- The odds of having higher score of enjoying sex per fortnight in those who had a boy / girlfriend in the network were 9 times those who did not have boy/girlfriend in the networks (OR- 9, 95% CI 1.67, 48.37, p= 0.01).
- The odds of having more than one partner per fortnight in those who had a boy/girlfriend in the networks were 4.6 times those who had no boy/girlfriend in the networks (OR- 4.6, 95% CI 1.47, 14.78, p= 0.009).

- The odds of having more than one partner per fortnight in those who had higher number of very close people in the networks (3-9) were 0.22 times those who had less than three very close people in the networks (OR- 0.22, 95% CI 0.07, 0.72, p= 0.01).

Summary of the findings

Demographic, sexual behaviours and social network variables

There were 86 participants in the baseline survey; their ages ranged from 15 to 17 years, 70% were female and 85% were born in Australia. They were enrolled in grades 9–12 of high school at baseline, and half of them reported excellent school performance. Half of the respondents' fathers were university educated, and three quarters worked full-time. More than 60% of their mothers were university educated and nearly half worked full-time.

Although 70% of participants were female, 49% were attracted to both sexes, while 51% were attracted solely to the opposite sex. Most of the participants (80%) were sexually active, reporting activity from deep kissing to intercourse. The mean age of first sexual activity rose linearly depending on the activity (e.g., 14.0 years for kissing and 15.9 years for anal sex). The percentage of participants who reported vaginal sex rose progressively over the three study time points: 57%, 75% and 80%. Engagement in anal sex showed a similar trend: 20% at T1, 29% at T2 and 35% at T3.

- The percentage of total respondents reporting multiple sex partners slightly increased with their age: 40% at T1, 48% at T2 and 52% at T3. The proportion of episodes of sex that involved a condom increased with age: 35% of respondents used a condom while having sex at T1, 63% at T2, and 70% at T3.
- The mean score of wanted sex (reported per fortnight) did not alter over time: 82 of 100 at T2 vs. 81 at T3. However, the mean score for how much the participant enjoyed sex decreased slightly, from 77.6 at T2 to 68 at T3.
- The mean value of degree centrality (the number of people in the network of a participant) was between 7 and 8 at all three time points. The proportion of high-degree centrality was 50% at T1 and T2, but 38% at T3, showing that the number of people in these adolescents' networks decreased with age.
- The mean value of the centrality of the betweenness did not change across three time points: 8.06 out of 10 at T1, 7.82 at T2 and 6.18 at T3. However, the percentage of high-betweenness centrality decreased slightly with age: 50% at T1, 48% at T2, and 45% at T3. This suggests that some adolescents did not occupy a high-betweenness position when they matured.
- The mean value of efficiency, around 0.5, did not vary across the three time points. The mean value of the constraint, around 0.4, remained stable.
- However, the maximum constraint value significantly increased with age: 0.63 at T1, 0.7 at T2 and 0.93 at T3. The mean value of average tie strength slightly reduced as participant grew older: 7.9 at T1, 7.6 at T2 and 7.5 at T3. The ego density remained at 0.6 across the three time points.
- The mean number of friends in the networks was 6 at three time points, but the percentage of those who had more friends the networks slightly decreased across three time points: 52% at T1, 49% at T2 and 36% at T3.
- The proportion of participants who had a boy/girlfriend increased with their age: 45% at T1, 48% at T2 and 55% at T3. The proportion with family members in their networks fluctuated across the three years of the research project cycle: 50% at T1, 44% at T2 and 56% at T3.
- The mean number of high school students in the participants' networks decreased significantly over time: 5 at T1, 4 at T2 and 2 at T3. Accordingly, the percentage of those with no high school students increased across time: 5% at T1, 17.46% at T2 and 38% at T3. The proportion of those

who had university students in the network increased with participants' age: 25% in T1, 54% at T2 and 65% at T3. The percentage of those who had nonstudents in the network increased: 55% at T1, 60% at T2 and 82% at T3.

- The percentage of adolescents who had a high number of very close people in their network decreased with time: 61% at T1, 59% at T2 and 28% at T3. The percentage of adolescents who had a high number of close people in the network also decreased with time: 67% at T1, 65% at T2 and 60% at T3. The percentage of adolescents who had one or more 'not really close' people in the networks was similar across time: 61% at T1, 65% at T2, and 60% at T3.

Social networks of the participants and their sexual behaviours

The association between the social network variables (exposures) and sexual behaviours (outcomes) measured at baseline were analysed with correlation analysis. We found the following.

- The number of sexual partners was negatively associated with the ego density ($r = -0.35$, $p < 0.05$) and positively associated with efficiency ($r = 0.36$, $p < 0.05$). Adolescents in networks in which people knew each other and interacted more frequently were less likely to have a higher number of sexual partners than those in networks in which people did not know each other and interacted less with each other.

- The experience of unwanted sex was positively associated with efficiency ($r = -0.31$, $p < 0.05$). Adolescents who were able to reach more people in networks through their primary contacts were more likely to experience unwanted sex than those who were unable to do so.

- The average strength of the tie was positively associated with ego density ($r = 0.7$, $p < 0.05$) and constraint ($r = 0.42$, $p < 0.05$). Emotional attachment, intimacy and spending time with people in networks of adolescents were stronger in networks in which people knew each other and interacted more frequently.

- Average tie strength was negatively associated with degree centrality ($r = -0.25$, $p < 0.05$), betweenness centrality ($r = -0.59$, $p < 0.05$) and efficiency ($r = -0.69$, $p < 0.05$). Emotional attachment, intimacy and spending time with people in networks of adolescents were less likely to happen in networks with a higher number of people with whom adolescents connected.

  Degree centrality was positively associated with betweenness centrality ($r = 0.59$, $p < 0.05$) and efficiency ($r = 0.26$, $p < 0.05$) and negatively associated with constraint ($r = -0.88$, $p < 0.05$). The number of people whom adolescents reached in networks was positively associated with being in a broker position. It was also positively associated with the ability of adolescents to reach more people in networks through their primary contacts. The number of people whom adolescents reached in networks was negatively associated with the time and energy invested in obtaining additional contacts.
- Betweenness centrality was positively associated with efficiency ($r = 0.79$, $p < 0.05$) and negatively associated with constraint ($r = -0.70$, $p < 0.05$). The ability of adolescents to have a broker position in networks was positively associated with their ability to reach more people in networks through their primary contacts.

- Efficiency was negatively associated with constraint (r = -0.51, p <0.05). The ability of adolescents to reach more people in networks through their primary contacts was negatively associated with the time and energy invested to obtain additional contacts.

The association between the social network variables (exposures) and sexual behaviours (outcomes) measured at baseline were analysed with bivariate and multivariate models, with the following results.

- Those who were sexually attracted to both sexes reported higher prevalence of anal sex (OR 4.4, 95% CI 1.10–7.92, p <0.05) (AOR 8.32, 95% CI 1.32–52.56, p < 0.05). Those who had higher efficiency (ability to reach more people in networks through their primary contacts) were also more likely to report anal sex (OR 7.65, 95%CI 1.5–38.99, p < 0.05) (AOR-7.57, 95% CI 1.19–47.91, p < 0.05).

- Adolescents who scored higher for efficiency (ability to reach more people in networks through their primary contacts) reported more sexual partners (multiple partners) (OR 4.44, 95% CI 1.11– 17.67, p < 0.05) (AOR 9.52, 95% CI 1.36, 66.79, p < 0.05). The number of sexual partners was lower among those who were in networks with high ego density (networks in which people knew each other and interacted more frequently) (AOR 0.07, 95% CI 0.006–0.77, p < 0.05).

- The mean age of first vaginal sex was later than 16 years in those who had higher degree centrality (more people reached in networks) (OR 4.11, 95% CI 1.02–16.67, p = 0.05). Those who encountered more constraints in the networks (time and energy invested to obtain an additional contact) were more likely to experience first vaginal sex before the age of 16 years (OR 0.24, 95% CI 0.06–0.98, p < 0.05).

- The experience of unwanted sexual activity was more likely to be reported by those adolescents who had a lower density of ego in their network (networks in which people knew fewer others and interacted less frequently) (OR 0.15, 95% CI 0.03–0.80, p < 0.05).

- Having sex without a condom was less likely to be reported by adolescents from high socioeconomic index areas (OR 0.10, 95% CI 0.02–0.57, p < 0.01; AOR 0.10, 95% CI 0.02–0.63, p < 0.05).

The association between social network variables (exposures) and sexual behaviour (outcomes) was assessed between baseline and midline with bivariate and multivariate analysis models. Our findings were as follows.

- Casual sexual partners were more likely to be reported by adolescents from high socioeconomic areas (OR 5.85, 95% CI 1.5–22.8, p < 0.05; AOR 5.51, 95% CI 1.18–25.83, p < 0.05), those who had a higher betweenness position (a broker position) (AOR 4.53, 95% CI 1.02–16.96, p < 0.05; AOR 6.78, 95% CI 1.28–35.96, p <0.05). Having casual sexual partners was also more likely to be reported by adolescents who had higher efficiency (able to reach more people in networks through their primary contacts) (OR 3.84, 95% CI 1.04–14.21, p < 0.05).

- However, having casual sex partners was less likely to be reported by those with a higher constraint in their network (those who needed to invest more time and energy to obtain an additional contact) (AOR 0.18, 95% CI 0.30–0.98, p < 0.05). Having casual sexual partners was also less likely to be reported by those who were from a higher ego density network (networks

in which people knew each other and interacted more frequently) (OR 0.26, 95% CI 0.07–0.96, p < 0.05).

- Adolescents who were sexually attracted to both sexes were more likely to report anal sex (OR 3.9, 95% CI 1.16–13.14, p < 0.05). Anal sex was less likely to be reported by adolescents living in high socioeconomic areas (OR 0.27, 95% CI 0.08–0.92, p< 0.05; AOR 0.24, 95% CI 0.06–0.98, p < 0.05) and those with a high tie strength in their network (OR 0.26, 95% CI 0.07–0.98, p < 0.05; AOR 0.21, 95% CI 0.05–0.96, p < 0.05).

Associations between social network variables (exposures) and sexual behaviours (outcomes) were assessed between midline and endline with bivariate and multivariate analysis models. Our findings were as follows.

- A higher mean score for wanted sex was reported by those who had higher tie strength in their networks (higher emotional attachment, intimacy and spending more time with people in networks) (OR 5.06, 95% CI 1.08–23.57, p < 0.05; AOR 4.5, 95% CI 1.31–15.41, p < 0.05).

- A lower mean score of having wanted sex was reported by female adolescents (OR 0.1, 95% CI 0.01–0.86, p <0.05), and other-gendered adolescents (OR 0.06, 95% CI 0.004–0.92, p <0.05).

- A higher mean score for enjoyment of sex was reported in adolescents who had a stronger average tie strength in networks (higher emotional attachment, intimacy and spending more time with people in networks) (OR 3.52, 95% CI 1.12–11.06, p < 0.03). In contrast, more efficient adolescents (adolescents with the ability to reach more people in networks through their primary contacts) reported lower scores for enjoyment of sex (AOR 0.23, 95% CI 0.066–1.07, p < 0.05).

A trend analysis was conducted using the GEE model, treating social network variables as exposures and sexual behaviours as outcomes. The results were as follows.

- The IRR of having a higher score for wanted sex per fortnight in those who had higher ego density (networks in which people knew each other and interacted more frequently) versus those who had lower ego density was 1.09 (95% CI 1.04–1.14, p= 0.001) in a GEE model adjusted for the time factor. The IRR of having higher score for wanted sex per fortnight in those who had higher betweenness centrality (a broker position in networks) versus those who had lower betweenness centrality was 0.95 (95% CI 0.90–0.99, p= 0.02). The IRR of having higher score for wanted sex per fortnight in those who had higher efficiency in networks (those with the ability to reach more people in networks through their primary contacts) versus those who had lower efficiency in networks was 0.95 (95% CI 0.90–0.99, p= 0.03).

- The IRR of higher score for enjoyment of sex per fortnight in those who had higher ego density versus those who had lower ego density was 1.04 (95% CI 1.04–1.15, p=0.001). The IRR of higher score for enjoyment of sex per fortnight in those who had high betweenness centrality versus those with lower betweenness centrality was 0.91 (95% CI 0.87–0.96, p < 0.001). The IRR of higher score for enjoyment of sex per fortnight in those who had higher efficiency in the networks versus those who had lower efficiency in networks was 0.87 (95% CI 0.83–0.91, p < 0.001).

Alters' variables and sexual behaviours of the participants

The association between the alters' variables (exposures) and sexual behaviours (outcomes) collected at baseline were analysed with bivariate and multivariate analysis models. We found the following.

- Those who had a boy/girlfriend in their networks were more likely to report prevalent of vaginal sex (OR 6.5, 95% CI 2.47–17.08, p < 0.001; AOR 9.02, 95% CI 2.72–3.00, p = 0.001).
- Those who were attracted to the same sex or both sexes were more more likely to report prevalent anal sex (OR 6.72, 95% CI 1.37–33.05, p = 0.02; AOR 6.91, 95% CI 1.32–36.08, p = 0.03).
- Those who had more than four high school students in their network were less likely to report more than one sex partner (OR 0.24, 95% CI 0.06–0.95, p= 0.04).
- Those who had more than five friends in their network were more likely to have their first vaginal sex experience after 16 years of age (OR 4.11, 95% CI 1.02–16.67, p= 0.04; AOR 6.6, 9% CI 1.18–36.72, p= 0.035), as were those who had more than five high school students in their network (OR 5.57, 95% CI 1.3–23.93, p= 0.02; AOR 7.9, 95% CI 1.41–44.71, p= 0.01) and those who had three or more very close people in their network (OR 6.9, 95% CI 1.03–45.83, p= 0.03). Those who had one or more non-student workers in their network were less likely to have first vaginal sex experience after the age of 16 years (OR 0.14, 95% 0.03–0.64, p= 0.01; AOR 0.06, 95% CI 0.008–0.4, p= 0.01).
- Those who had a boy/girlfriend in their network were more likely to report having sex without a condom (OR 11.5, 95% CI 2.54–52.05, p= 0.002; AOR 34.07, 95% CI 2.59–448.88, p = 0.04). Those who were attracted to both sexes were more likely to have sex without a condom (OR 4.0, 95% 1.05–12.26%, p = 0.03). Those who resided in higher socioeconomic areas were less likely to report sex without a condom (OR 0.10, 95% CI 0.02–0.57, p = 0.01), (AOR 0.10, 95% CI 0.01–0.64, p = 0.01). Those who had more 'not really close' people in their network were also less likely to report sex without a condom (OR 0.25, 95% CI 0.06–0.97, p = 0.046).

Association between the alters' variables (exposures) and sexual behaviours (outcomes) collected at baseline and midline surveys were analysed with bivariate and multivariate analysis models. Our analyses produced the following results.

- Those who had university students in their network were more likely to report having casual sex partners than those who did not (OR 5.85, 95% CI 1.59–23.57, p= 0.009; AOR 7.09, 95% CI 1.38–36.48, p = 0.019). Those who resided in a high socioeconomic are were also more likely to report casual sex partners (OR 5.85, 95% CI 1.5–22.8, p < 0.05; AOR 4.35, 95% CI 1.04–18.12, p < 0.05).
- The mean score for enjoyment of sex per fortnight was lower in those who had more than five friends in their network (AOR= 0.22, 95% CI 0.06–0.81, p = 0.02).
- A higher number of sexual partners per fortnight was reported by those who had a boy/girlfriend in their network (OR 3.8, 95% CI 1.32–10.9, p = 0.0013; AOR 3.55, 95% CI 1.16–10.87, p = 0.027).

The association between the alters variables (exposures) and sexual behaviours (outcomes) collected between midline and endline surveys were analysed with bivariate and multivariate analysis models. We found the following.

- Those who had university students in their network were more likely to report casual sex partners (OR 5.78, 95% CI 1.52–21.93, p= 0.01; OR 21.47, 95%CI 1.86–248.99, p= 0.014). However, those who had more friends in their network were less likely to report casual sex partners (OR 0.21, 95% CI 0.06–0.81, p= 0.02; AOR 0.21, 95% CI 0.43–0.99, p= 0.049). Those who had a boy/girlfriend in their network were also less likely to report causal sex partners (OR 0.23, 0.06–0.88, p = 0.03; AOR 0.17, 95% CI 0.03–0.84, p= 0.03).

- Older adolescents were more likely to report prevalent vaginal sex than those who were younger (OR 1.03, 95% CI 0.24–4.49, p =0.03). Those who had a larger number of very close people in the network were less likely to report vaginal sex (AOR 0.01, 95% CI 0.00–0.81, p = 0.04).

- Those who had university students in their network were more likely to report a higher average number of episodes of sex with a condom per fortnight (OR 7.7, 95% CI 1.67–35.51, p = 0.038; AOR 10.63, 95% CI 1.14–98.91, p = 0.03). Those residing in a high socioeconomic area were more likely to report a higher average number of episodes of sex with a condom per fortnight (OR 3.38, 95% CI 0.95–12.01, p= 0.059; AOR 11.32, 95% CI 1.68–76.10, p= 0.013).

- Those who had a boy/girlfriend in their network had a higher average score of having wanted sex (OR 3.63, 95% CI 1.07–12.30, p = 0.04; AOR 4.56, 95% CI 1.12–18.53, p = 0.034). In contrast, those who had university students in their network were less likely to report having wanted sex (OR= 0.19, 9% CI 0.05–0.72, p = 0.01; AOR 0.05, 95% CI 0.004– 0.56, p = 0.02). Those who had family members in their network were also less likely to report having wanted sex (OR 0.26, 95% CI 0.09–0.86, p = 0.027).

- Those who had a boy/girlfriend in their network showed a higher average score for enjoying sex (OR- 9, 95% CI 1.67, 48.37, p= 0.01; AOR- 12.78, 95% CI 1.48, 110.39, p= 0.021)

- Those who had a boy/girlfriend in their network were more likely to report having more than one sex partner per fortnight in (OR 4.6, 95% CI 1.47–14.78, p= 0.009; AOR 5.81, 95% CI 1.54–21.85, p = 0.009). Those who had a larger number of very close people in their network were less likely to report having more sex partner per fortnight (OR 0.22, 95% CI 0.07–0.72, p = 0.01; AOR 0.26, 95% CI 0.07–0.93, p = 0.04).

5. Discussion

Social networks and sexual behaviours

We found novel associations between the social networks and sexual behaviours of adolescents, as well as between alters' variables and the sexual behaviours of adolescents. The results indicate that the properties of social networks exert powerful influence on the sexual behaviours of adolescents. We should also aware that the context of adolescence is also influenced by other factors, such as ongoing development toward maturity and their tendency to engage in risk-taking behaviours (Patton et al., 2016b).

Tie strength and ego density

Adolescents who had stronger ties with the people in their networks (alters) were more likely to report having sex with the person they wanted to have sex with, and greater enjoyment of their sexual activities than those who had weaker ties with the people in their networks. Adolescents with a network in which members were well connected to each other (high ego density) were less likely to engage in risky sexual behaviours than those with a less connected network. They were less likely to have a high number of casual sexual partners, and reported fewer unwanted sexual experiences prior to the baseline survey. These findings were supported by the findings of the longitudinal analyses: adolescents with well-connected networks were more likely to have sex with whom they wanted, and to enjoy the sex, than those who had a low ego density. These are novel findings our study explored.

These results represent unprecedented insight into how adolescents' social networks affect their sexual behaviour. The tie strength between the adolescent respondents and the people in their networks was associated with less risky sexual behaviours and pleasurable, desired sex. These are components of healthy sexual development for adolescents. It could be suggested that a dense network maintains the norms and practices accepted in that network and protects from external information sources and influences of risky behaviours practised outside their networks (Thomas W Valente, 2010). A previous study found that people with dense networks were more likely to follow traditional norms (Prell, 2011); these prevailing norms and practices protect from outside influences (Thomas W Valente, 2010). Another study inferred that if the group is well contained and protected from outside contacts, the group remains immune and risk-free (Thomas W Valente, 2010). Kornhauser's theory of social disorganisation also suggests that adolescents with strong social structures are at the lowest risk of engaging in potentially harmful behaviours due to the informal control of the community in social networks (C. Browning et al., 2004; Sampson & Groves, 1989; Wilson, 1996).

Since most of the study sample were students, it was assumed that the norms in their existing networks were relatively healthy – meaning they were at low risk of the more dangerous STIs such as HIV, syphilis and gonorrhoea. This assumption correlates with diffusion innovation theory (Thomas W Valente, 2010) and the homophily concept (McPherson, Smith-Lovin, & Cook, 2001). The diffusion of new behaviour might be slow in a dense network made up of people with similar beliefs, attitudes and status, because the threshold for adopting new ideas would be similar for most network members. This explains why, the sampled adolescents with well-connected peer networks, which were mainly composed of high school students, were more likely to maintain their existing norms. The recent systematic review conducted in 2020 for peer social network processes and adolescent health behaviours found that health behaviours similarity within were driven by homophilic social selection,

and adolescents in denser networks had significantly lower levels of harmful behaviours (Montgomery et al., 2020).

Betweenness centrality and efficiency

Contrary to expectations, adolescents with higher betweenness positions and high efficiency in their networks were not well protected in terms of healthy sexual behaviours. Adolescents who had higher betweenness positions in their networks were more likely to have casual sexual partners. The longitudinal data analysis across three time points also showed that they were more likely to have sex with people they did not want to have sex with, and gave lower scores for having enjoyable sex than those who had lower betweenness positions. This is exactly the novel finding which we should be aware of in the context of adolescents' healthy sexual development.

This finding contrasts with those from studies of business networks, which show that higher betweenness positions were associated with becoming a successful businessperson (Dunn, 2019; Karkavandi, 2019). It can be argued that adolescents with high centrality function as a bridge between network members who are not connected. As a result, they can be exposed to and adopt new beliefs, norms and behaviours earlier than others (Thomas W Valente, 2010). New beliefs and ideas are not necessarily positive – they could act as catalysts for adolescents' decisions to undertake risky sexual behaviours.

Some studies of the HIV/AIDS epidemic suggest that persons at bridging positions serve as intermediaries between groups; for example, a sex worker infects customers, who then transmit the infection in new networks (Jacobson, 1970; Klovdahl, 1985; Little, 1960). Although the definition of betweenness in these studies was not identical to that used in our own, their findings on bridging positions reflect the behaviours of adolescents who have an in-between position in terms of sexual contacts.

The findings of this study on betweenness are consistent with Bettinger (2004), who investigated the association between the bridge position in social networks and the perception of sexual risk and condom use among adolescents. He found that those holding bridging positions were more likely to have lower risk perceptions than those in the network periphery, and that they neglected safe practices such as using condoms (Bettinger et al., 2004). Adolescents with a high betweenness position can also perceive themselves as being at low risk and engage in risky sexual behaviours unintentionally.

A recent study of social networks with respect to conspiracy theories about COVID-19 suggested that someone could have a high betweenness position regardless of their status in the network (W. Ahmed et al., 2020). This suggests that an adolescent could have a high-betweenness position in a social network despite their low popularity. Therefore, both popular and less popular adolescents on networks have opportunities to engage in risky sexual behaviours as long as they are in a high-betweenness position.

Our study found that adolescents who were more efficient in their networks (i.e., greater number of possible friendships per each primary contact) were more likely to have a greater number of sexual partners in the six months prior to the baseline survey than those who were less efficient in their networks. The longitudinal analysis showed that the score of having wanted sex and enjoying sex was lower in those who were more efficient in the networks. Our results conflict with those of previous research on efficiency of people in business sector networks, in which successful managers were those who were more efficient in communicating with various firms, taking a bridging position (Ronald S Burt, 2004; Thomas W. Valente, 2005). In the context of adolescence, we should remember that

development is ongoing – their management capabilities have not matured. Adolescents' drive to explore and discover can overrule reason, and as a result, they are prone to risk-taking behaviours (Patton et al., 2018; Patton et al., 2016b).

Our analyses produced some evidence that the central person in the network achieved positive or negative outcomes depending on the aspects of the networks in which they were embedded (Borgatti et al., 2013). Moreover, high betweenness centrality and efficiency could change the behaviours of adolescents depending on the group with which they communicated. A previous study suggested that homeless adolescents who developed a network with friends who had homes reported lower levels of adverse health behaviours, such as reduced depressive symptoms, than those who did not have friends with homes (Eric Rice et al., 2012), and decreased rates of transactional sex (S. D. Young & Rice, 2011), and other risky sexual behaviours (E. Rice et al., 2007). In contrast, in our study, adolescents who had a high-betweenness position and high efficiency reported more risky sexual behaviours, possibly due to the persons with whom they interacted in their networks.

Recall that 70% of the participants in this study reported attraction to both sexes. Online platforms offer access to the LGBT community, assist people to accept their identity, and offer a sense of belonging; at the same time, they may introduce them to sexual risk behaviours such as multiple casual sex partners (Shilo & Mor, 2015). In this study, those who had higher betweenness centrality and higher efficiency communicated with LGBT community networks in search of a positive environment, information about LGBT youth, and to find like-minded friends, as well as to hook up with casual sex partners, which could expose them to risky sexual behaviours.

Degree centrality

The findings revealed that adolescents who had more people in their networks were more likely to have their first vaginal sex after 16 years of age than those who had fewer people in their networks. In our study, most of the participants' peers were high school students. Therefore, the attachment of high school students to peers could secure a sense of belonging (Reiner et al., 2017) to adolescents and therefore they would be less likely to engage in early sex. The report of Australian Institute of Health and Welfare (2022) also highlighted that school environment plays a crucial role in terms of the quality of social networks of adolescents due to the stronger sense of belonging. Adolescents who had more friends were more likely to be self-confident, good social and emotional skills (AIHW, 2022).

Valente and Saba (1998) found that people with a minority of egocentric network members relied on information sourced from beyond their existing network for their decision-making (Thomas W Valente, 2010). In our study, adolescents who had fewer people in their network were more likely to find new ideas from outside sources than within their existing networks. New ideas outside of their routine network could promote or undermine the safety of their sexual behaviour.

Interpretation of SNA findings is highly dependent on the nature of the network. Although a greater degree of centrality (the number of people in the network) in the organisational management sector represents success, that indicator in infectious disease epidemiology corresponds to a higher chance of infection due to increased exposure (Borgatti et al., 2013). The recent studies convinced that the type of peers in the network can change the sexual behaviours of adolescents. The study in Ghana of 360 high school found that those who had high number of friends who had sex was associated with an early sexual debut (Akumiah et al., 2020). The study of 2,573 Russian adolescent aged 13-17 years old reported that affiliating with bad peers were strongly associated with risky sexual behaviours

(Isaksson et al., 2021). The study of 338 adolescents in Ethiopia also found that risky sexual behaviours were associated with peer pressure (AOR=5.82, 95 CI 2.97-11.41). (Bhushan et al., 2022)

Constraints

The finding of an association between the constraint variable and the sexual behaviour of adolescents is perplexing. When the people in the network know each other and closely connected, the network has higher constraint on adolescents to get additional contacts in networks. Those who had more constraints in their networks were more likely to have their first vaginal sex earlier than 16 years of age. However, the p-value for this association is 0.048, therefore the evidence against the null hypothesis is far from strong.

Those who had higher constraint were less likely to have casual sexual partners and to report anal sex than those with low constraints. This could be interpreted as meaning that heterosexual adolescents with high constraint had a lower chance of meeting people from diverse backgrounds. They mostly met people with similar backgrounds, formed stable networks and did not report casual partners.

Alters' variables and sexual behaviours of the participants

Results confirmed that the characteristics of people in the adolescent participants' networks affect the latter's sexual behaviour.

Closeness

This study provides striking evidence that the presence of close people in networks plays an important role in the sexual behaviour of adolescents. Those adolescents who had a larger number of very close people in their network were more likely to initiate their first vaginal sex after 16 years of age, less likely to be sexually active, and less likely to have multiple sexual partners.

The longitudinal data supported the cross-sectional data. Adolescents who had more very close people in their network had higher scores for enjoyment of sex (on average) than those who had more people 'not really close' in their network. These results confirm previous findings in the literature that networks that included close people made network members feel a sense of belonging (L. E. Young et al., 2018a), supported disclosure of their concerns (McFadden et al., 2014), assisted in supporting each other to pass hard times (Wu et al., 2015). Having a close network was negatively associated with having sex in another study (C. R. Browning, B. Soller, & A. L. Jackson, 2015a); sexual intercourse was less likely to occur in those who had a larger number of very close people in their network. This finding concurs with Browning (2015) that network enforcement in neighborhood networks exhibits a negative association with ever having sex (C. R. Browning et al., 2015a).

Peers

This study strengthened the evidence on the impact of peers (friends and high school colleagues) on the sexual behaviours of adolescents. Adolescents who had a higher number of high school peers in their networks were more likely to initiate their first sex experience after the age of 16 years, and reported fewer sex partners than those who had a smaller number of high school peers in their network at the beginning of the study. Adolescents who reported more friends in their networks were more likely to engage in vaginal sex for the first time after the age of 16 years, to have lower scores for enjoying sex at midline, and to report casual sex partners at the end of the study. Lower scores for enjoying sex could be due to these adolescents reporting fewer sexual experiences. Otherwise, the findings suggest that having high school student peers in an adolescent's network is protective against risky sexual behaviours.

The study findings showed an optimistic picture of the influence of peers on the sexual behaviours of adolescents. This was in contrast to previous studies, which highlighted an association between peer interactions and harmful health behaviours. A study showed that early sexual experience occurred more often among adolescents who could not overcome peer pressure in networks that favoured early sex (Majumdar, 2006). However, a few studies have found a positive effect of peers on adolescents' sexual behaviours. Among them, Mladenovik (2020) found that higher peer frequency was a protective factor for the age of onset of sexual activity among adolescents in Macedonia, and Rice (2010) showed that homeless youths having home-based peers in their networks could lead to a reduction of risky sexual behaviours. These findings illustrates that the health benefits of social networks depend on the type of person with whom adolescents communicate.

The Theory of Reasoned Action (Ajzen, 1991) states that people's behaviour is determined by their intentions, which in turn are shaped by interactions between attitudes, perceived norms, and perceived control or degree of autonomy. In the case of adolescents, perceived norms refer to the social norms of peers. In this study, those who had more high school students in their network might want to adopt group norms that could promote healthy sexual behaviour. Adolescents who had many high school students and friends in their network might follow their peers in thinking that they should focus on their studies rather than social and sexual relationships. At the same time, according to the homophily effect (Trinh, Lee, Halpern, & Moody, 2019), adolescents might seek out friends who are minded to spend more time studying than engaging in sex. Satisfying the sense of belonging and the requirement of adherence to group norms may result in healthy sexual behaviours.

Thomas W Valente (2010) asserted that people who belong to the same group engage in the same behaviours. In this study, someone who had more high school students in networks had a greater potential to conform to the perceived group norm on healthy sexual behaviour. These findings were also consistent with the social learning theory of Bandura (1986), which states that people adopt the behaviours which others praise (Thomas W Valente, 2010). In this study, adolescents who had more high school students and friends in their networks could follow the sexual behaviours of role-model students. Moreover, schools function as a protective factor for young people, providing safety, motivation, relationships and support for positive student outcomes (Osher, Kendziora, Spier, & Garibaldi, 2014).

The study findings also indicate that the educational level of members of the network can change the sexual behaviours of adolescents. Those who had university students in their network were more likely to have casual partners and more likely to use condoms (at the end-line survey). The use of condom could be due to having sex with casual partners; however, they were also more likely to have unwanted sex, according to cross-sectional analysis. Those who had more high school students in their networks were less likely to have their first sexual experience before 16 years of age than those who had fewer high school students in their network.

These results indicate that adolescents' sexual behaviours advanced when their social network expanded beyond high school peers. These findings were the result of the changing variables of alters, rather than the adolescents ageing, because age was controlled for in multiple logistic regression models. A greater number of high school students in a network could provide an environment for developing healthy sexual behaviours. Conversely, having university students in the network seems to be safer than having non-student workers in the network, because the former group was associated with increased condom use. These findings are supported by the work of (Sklenarova et al., 2018), who revealed that German adolescents in social interactions with non-student adults were more likely to have negative experiences such as being tricked, coerced or victimised. Another study reported that LGBT adolescents who had older friends had higher prevalence of sexual risk behaviours (Finneran & Stephenson, 2014).

Demographic variables and sexual behaviours of the participants

Age

Older adolescents were more likely to report active vaginal status than younger ones. The participants consistently described a hierarchy of sexual behaviours in terms of age: kissing, touching of each other's genitals, oral sex, vaginal sex, and anal sex. This hierarchy followed the typical sequence found in previous research (Temple-Smith et al., 2015).

Gender

It was unsurprising to discover that females were more likely to report vaginal sex, whereas the 'other' gender group was more likely to report anal sex. Although not anticipated, the results indicated that the female and 'other' gendered respondents scored lower in wanting sex with the person with whom they had sex than the male respondents. This could be due to male adolescents being more likely to engage in sexual activity than female adolescents (Harrison et al., 2012) and more sexually experienced than female adolescents (Traeen & Kvalem, 1996). These finding was supported by findings from studies of adults that men usually expressed higher levels of relationship satisfaction than women (Richters, Grulich, de Visser, Smith, & Rissel, 2003) and females reported inhibited sexual desire and had fewer orgasms during shared sexual experiences (Nutter & Condron, 1983).

Socioeconomic status

The results of the study are consistent with earlier findings about the socioeconomic status and sexual behaviour of adolescents. Young people living in higher socioeconomic areas were more likely to use condoms than those in lower socioeconomic areas. The results on condom use ware consistent with an earlier study from Brazil that pointed out that adolescents from low-income families did not use contraception regularly (Ahinkorah, 2020; Menezes et al., 2016; J. Smith, 2020). The recent study of 659 adolescents in Ethiopia also found that those who lived in poor social support area were more likely to have risky sexual behaviors (Srahbzu & Tirfeneh, 2020), and those who were from poor neighborhood were linked to early sexual initiation (Orihuela et al., 2020).

Strengths and limitations of the present study

Some limitations of this study are acknowledged and should be taken into account when reflecting on its results. The primary limitation of the present study is the generalisability of our sample size to adolescents in the general population in Australia. There is a chance of both random sampling error due to the small sample size and selection bias due to the convenience recruitment method in sampling participants from reproductive health clinics and online social sites. The participants may represent adolescents who are more interested in sexuality and online solicitation than most Australian young people. They could be more confident, outgoing, and more likely to engage in sex than those who did not participate, so may have responded to the survey differently. However, researchers on sexual behaviours and social networks are increasingly recruiting participants using convenience sampling and online recruitment systems.

The participants in the present study were mainly female (70%); however, half of all participants were interested in the same sex or both sexes. This composition is different from the general adolescent population of Australia, which has a nearly even split between males and females, and only 15% are interested in same-sex behaviours (Christopher M Fisher, 2019). However, the populations' characteristics are similar in many respects. Eighty per cent of our participants were sexually active, and the mean age of first vaginal sex was 15 years. Their age of first sexual activities were: first deep kissing at a mean age of 14 years, first touching the genitals at 14.80 or being touched by others at 14.65, first giving oral sex to others at 14.95 and receiving oral sex at 15.11, first vaginal sex at 15.10, first anal sex at 15.90, and first sex without condom at 15.50 years of age. These findings are similar to those of the general adolescent population (Christopher M Fisher, 2019). Therefore, it is arguable that our findings are representative of the general adolescent population in terms of behaviour.

Another limitation of the present study concerns the justification of the sample size, which was unclear in SNAP project documents. However, it was hard to anticipate the required sample size in the absence of previous similar studies to predict the risk difference or risk ratio for use in the sample size formula. The sample size was small compared to those of other cohort studies, which could undermine quantitative inference; some of the ORs and IRRs had wide confidence intervals (Kirkwood & Sterne, 2010). Due to the small sample size, the distribution of some variables was skewed, and there were nonlinear associations between exposure and outcome. Therefore, a logistic regression with a maximum of two categories was chosen in each exposure variable. That made it difficult to prove the dose–response effect of the association between categorical exposures and their related outcomes. A larger sample would have provided more precise estimates of the true association with minimum random sampling errors.

The analysis included the most important confounders – age, gender, and socioeconomic status – in the multiple logistic regression models. With a larger sample size, there would have been more room for comprehensive multiple logistic regression models in which both social network variables and alters variables could have been included. As a result, it was not feasible to determine whether adjusted confounders acted as confounders only or both confounders and effect modifiers. With a larger sample size, it would have been possible to report ORs and IRRs for different groups of exposure variables, such as male vs. female and high socioeconomic status vs. low socio-economic status.

Multiple logistic regression models allowed us to examine the simultaneous effects of exposures on the outcome variables. The analyses were robust because detailed epidemiological research

procedures such as testing normality of the variables, checking the collinearity of the variables, and sensitivity analyses were applied. The retention rate of 64% at the end of the study was reasonably high to cover the loss in follow-up cases. Repetition of multiple data such as fortnightly diaries over 18 months produced rich data to conduct both cross-sectional and longitudinal analyses.

Another strength of the study was an interdisciplinary approach that provided a better understanding of the social networks and sexual behaviours of adolescents. The survey tools used in the research were validated tools: sexual behaviour questionnaires were adopted from the National Survey of Australian Secondary Students and Sexual Health (2013); the diary questionnaires were developed based on the validated scale published by Vannier and O'Sullivan (A. Mitchell, 2014), and the social network tool was developed based on Burt's previous work (Ronald S. Burt et al., 2013).

The SNAP study used the same data collection tools for the baseline, midline and end line surveys, and the same diary questionnaires for all fortnightly online surveys. When transforming the numerical variables to categorical variables, the median value was selected for both the exposed and unexposed groups equally. Therefore, the measurement error was presumed to be minimal and the reproducibility of the research findings to be high.

Recall bias (differential misclassification) was minimal because adolescents reported their sexual experiences every fortnight. SNAP was a longitudinal cohort study, so the exposures (social network variables) were collected before the outcomes measure (sexual behaviours) appeared; therefore, the results are more reliable in terms of casual factors in epidemiology. Also, social desirability bias was minimal due to the nature of online surveys, and interviewer bias was non-existent because the surveys and diaries were self-administered and completed online. Participants had total control over the information they provided about their sexual behaviour in these online surveys.

The research findings maintained the temporality of exposures and outcomes, since longitudinal data analysis was used in which exposures occurred earlier than outcomes. The associations found were still significant after controlling for potential confounders in the multiple logistic regression models. Most of the findings were consistent between the cross-sectional and the longitudinal analyses. The findings mostly agreed with those of previous studies, and in some cases were novel. Some of these novel findings were supported by theories, despite there being no similar previous empirical studies. In summary, the results provide valid answers to the question of whether social network variables and the variables of network members influence the sexual behaviours of adolescents.

We used the egocentric approach to SNA, which is based on participants' reports of alters' information, which could differ from the alters' actual behaviours. However, the collection of egocentric data on alters' variables has been shown to have good validity (Aral et al., 1999). Moreover, the patterns of social networks observed in the present study concorded with the patterns found in other social network studies. Finally, it is possible to generalize the findings of this study to other countries which have similar context to Australia, but not to every part of the world.

Implications for research and policy

The present study suggests that adolescents from denser networks, those with stronger ties to the people in their networks, and those with a greater number of friends and high school students in their networks had safer sexual behaviours. The findings suggest that the properties of the social network

of a person should be considered from several perspectives, such as the node level, tie level and the network level, as well as the variables of the other people in the network.

The findings also illustrate that social networks are associated with adolescents' sexual behaviours in both constructive and potentially harmful ways. Policymakers should consider these findings in the design of healthy relationships education and health promotion. For example, future sexual health education could promote opportunities for collaborations and connections between friends of friends in networks. By this means, networks of adolescents can be made denser, promoting enhancement and transmission of existing knowledge about sexual and reproductive health in the network, and healthy sexual behaviour as a consequence.

The findings of our study provide guidance for parents and teachers to create safer networks for children. However, it is hard to contain young people in a well-connected world, especially when exploration of sexuality in digital spaces is very common. Therefore, it is important to encourage adolescents to be aware of social network concepts, to reflect on their benefits and setbacks, to be aware of their positions and the influence of others in their networks. It is also important to translate research findings into constructive messages for adolescents that inform life skills enhancing the healthy sexual development.

Finally, the findings of the present study show that online social networks have both good and bad aspects. At the same time, the education sector must work to develop skills in adolescents that are appropriate to the changing technological context of their communications and social lives. Health systems can also play a valuable role in providing promotion, prevention and care services that are tuned towards the healthy sexual development of adolescents.

Conclusion

Our SNA answered the questions we raised in the systematic review (Chapter 3). One of the findings of our systematic review is that the connection to school is negatively associated with having sex. This finding is supported by our SNA, which showed that adolescents who had more high school students in their networks were less likely to have sex before age 16. The other finding of the systematic review is that peer interaction is associated with having sex or early sexual experience positively or negatively depending on gender. That finding is validated by our SNA results showing that those who had more peers (friends or high school students) in their networks were less likely to report sex before age 16.

Our study also answered our research questions. Adolescents who had high personal network density (in SNA terminology, high ego density) and well-connected networks (strong tie strength) reported healthy sexual behaviours such as lower numbers of sexual partners, less experience of unwanted sexual activity, and greater enjoyment of sex. Adolescents who had a high brokerage position (high betweenness centrality and high efficiency) were more likely to report risky sexual behaviours such as experience of unwanted sex, high numbers of sexual partners, and having casual sex partners. Adolescents who had a higher number of people in the network did not practice risky sexual behaviours if the network was composed of more high school students. Qualitative studies should investigate the data for more understanding.

This study is a novel step toward improving our understanding of how the social networks of adolescents and the characteristics of their network members shape sexual behaviours. The findings improve our knowledge about sexual behaviour in adolescents, particularly with respect to the

intersection of social networks, behaviour and rapidly evolving digital communication technologies. This study provides parents, teachers, and health workers with new information on the complex contexts of modern adolescents' social networks and how they shape their sexual behaviours.

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