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SYSTEMATIC REVIEW

Peer-Friendship Networks and Self-injurious Thoughts and Behaviors in Adolescence: A Systematic Review of Sociometric School-based Studies that Use Social Network Analysis

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Abstract

Peers, particularly in-school peers, shape adolescent health behaviors. Yet little is known about in-school peers and self-injurious thoughts and behaviors. This systematic review examined studies of sociometric school-based adolescent peer-friendship networks and associations with self-injurious thoughts and behaviors. A search across five databases identified fifteen eligible studies. Studies were mainly longitudinal (n=13), from two countries (USA and China), of adolescents aged 11-19 at baseline, mostly balanced in gender (46%-56% girls), and from middle/high schools ranging in size (n=348-13482). Studies assessed 1) network structure and 2) exposure to friends' self-injury and suicidality. Friends' self-injurious thoughts and behaviors were associated with adolescents' own similar behaviors, but there was limited evidence for socialization and selection. Sociality and network density were negatively associated with self-injurious thoughts and behaviors, whereas isolation and intransitivity were positively associated. While study heterogeneity made it difficult to draw further conclusions about specific network metrics (e.g., centrality, reciprocity), studies indicate overall that peers matter for these behaviors across adolescent development (e.g., early to late adolescence). Like other adolescent behaviors, the structure of how youth are connected to peers also relates to self-injurious thoughts and behaviors. Future work should examine these processes over the course of adolescent development.

Keywords Self-harm · suicidal ideation · suicide attempts · social networks · peers · adolescence

Introduction

Self-injurious thoughts and behaviors are a major clinical and public health challenge. The term encompasses suicidal ideation, suicide attempts, and self-harm, and these behaviors are inextricably linked: self-harm is a leading risk factor for later suicide, and it is estimated that more than 700,000 die by suicide each year worldwide (World Health Organization 2021). Self-injurious thoughts and behaviors affect people of all ages. However, they are particularly common among adolescents. Prevalence estimates in community-based samples suggest that around 17% of adolescents have self-harmed at least once in their lifetime (Gillies et al. 2018), and the behavior often peaks during mid-adolescence (Plener et al. 2015). Social relationships, like a person's friendship circle, are increasingly recognized as key determinants of health and behavior (Montgomery et al. 2020). Given that self-injurious thoughts and behaviors peak in adolescence, a time when the school environment is salient and school-peers become a major social focus (Eccles and Roeser 2011), it is possible that in-school peers influence the development and maintenance of these behaviors. Yet little is known about school-based friendship networks and these behaviors among adolescents. This systematic review synthesizes evidence from sociometric studies of school-based peer-friendship networks and self-injurious thoughts and behaviors in adolescence.

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Adolescence is a developmental period where youth become highly attuned towards their social relationships with peers, particularly in-school peers (Brown and Larson 2009). School is also an environment where most adolescents typically spend a large amount of time (Eccles and Roeser 2011). The social influence of peers can be pivotal, and theoretically, models of self-harm and suicidal behavior support this social argument e.g., the four-function model of self-harm (Bentley et al. 2014) and the interpersonal theory of suicide (Van Orden et al. 2010). Studies have found that peers can affect adolescent health behaviors pertaining to substance use (Leung et al. 2014), sexual behavior (Potard et al. 2008), risk-taking behavior (Blakemore 2018), and suicidal behavior (Jarvi et al. 2013). A key risk factor for the transition between suicidal thinking and attempts in young people is being exposed to self-harm among friends (Mars et al. 2019). Likewise, adolescents who engage in self-harm are more likely to have friends who self-harm (Syed et al. 2020), and self-harm by best friends and the wider friendship group is associated with subsequent self-harm in young people (You et al. 2013). Friendship is an important relationship in adolescence (Youniss and Haynie 1992), particularly for self-harm, as friends may act as an initial first-line of support (Hall & Melia, 2022). There are also gender differences in the emotional and developmental trade-offs that come attached with peer relationships (Rose and Rudolph 2006).

School-based peer-friendship networks can be thought of in a multiplicity of ways. In a structural sense, certain positions, and integration within a school-based peer-friendship network may have certain risks or be protective for a young person's wellbeing. For example, one study found that for girls, high peer popularity (i.e., having more friends) and low cohesion (i.e., friends being disconnected) were associated with more depressive symptoms (Falci and McNeely 2009). This pattern suggests that social networks can be large for girls but may only be protective when friends are friends with one another. By contrast, high levels of cohesion were associated with worse mental health for boys and boys in fragmented networks reported lower levels of depressive symptoms (Falci and McNeely 2009).

Social networks may also facilitate transmission of behavior. Behaviors have the potential to transmit through a network via socialization (i.e., an individual is influenced by the behaviors of their peers), selection (i.e., an individual chooses to befriend peers with similar behaviors to them), or both. Peer influence research suggests there is some evidence of direct socialization among adolescent peers for externalizing behaviors such as health-risk behaviors (e.g., drinking alcohol) (Leung et al. 2014). Transmission effects have also been found for aspects of mental health like depressive symptoms among young people (Prinstein 2007; Stevens and Prinstein 2005), and influence processes can be gender specific (Fletcher, 2017). Given that typically adolescents spend a large portion of their youth in school, and that self-injurious thoughts and behaviors are linked, adolescents' interactions with their peers in school may provide a key environment for the diffusion of self-injurious thoughts and behaviors.

Two prior systematic reviews found that social networks are important in adolescence for self-injurious thoughts and behaviors (Jarvi et al. 2013; Quigley et al. 2017a). One review found that adolescents' non-suicidal self-injury was influenced by their social networks (Jarvi et al. 2013). A second review found positive associations between a young person's suicidal and self-harming behaviors and that of the people they know from a review of 86 papers (Quigley et al. 2017a). However, the two prior systematic reviews collate information from, primarily, studies that use a measure of an adolescent's *perception* of their friend's self-injurious thoughts and behaviors (peer-norm research). Peer-norm research is useful, but there may be a discrepancy between a *perceived* behavior of a friend and a friend's *actual* behavior (Quigley et al. 2017b). This discrepancy may be even greater for internalized and stigmatized processes like self-injurious thoughts and behaviors, whereby adolescents who self-report their friends' suicidal behavior may be prone to projection bias (i.e., over-estimating a friend's behaviors based on their own behaviors), which may lead to inaccurate conclusions about peer influence and peer selection of self-injurious thoughts and behaviors (Prinstein and Wang 2005).

Unlike peer-norm measures that measure an adolescent's *perception* of their friends, sociometric data can measure the friend's own reported behaviors. Sociometric 'whole network' data (i.e., data showing the relationships between different members in a group such as friendships) are unique in that they are bounded to a group or setting (e.g., a school), which enables school peer-friendship networks to be mapped out to see how individuals are positioned in their network or if there are network-wide and/or proximal-peer group features and processes present (Wasserman and Faust 1994). To know if an adolescent's behavior has been influenced by their friends, it must be known 'who is friends with whom': therefore, it can be argued that sociometric data are a *requirement* for the study of socialization and selection of behaviors, and specific network models (e.g., stochastic actor-oriented models [SAOMs]) are required to test these processes (Snijders et al. 2010). A review focusing on sociometric studies would help to better understand the social network processes that might impact adolescents' self-injurious thoughts and behaviors and vice versa.

Current Study

Focusing on sociometric studies that examine the association between school-based peer friendship networks and self-injurious thoughts and behaviors in adolescence is important methodologically and conceptually. Methodologically, sociometric data measures a friend's self-reported behavior (not an adolescent's perception of a friend's behavior) and can show the structure of how youth are embedded within the overall school network, a factor long associated with adolescent behavior and well-being (Montgomery et al. 2020). Conceptually, self-injurious thoughts and behaviors are a major health challenge among adolescents, and studies have shown that, despite being largely internalized and stigmatized, they may also be shaped by peers. Yet reviews of sociometric research on peer-friendship networks have tended to focus on externalizing health behaviors among adolescents (e.g., alcohol consumption), leaving a gap in reviewing research on the same factors for self-injurious thoughts and behaviors. Therefore, understanding how sociometric in-school peer networks relate to self-injurious thoughts and behaviors is important for tackling this health challenge. The present study addressed this gap by conducting a systematic review of sociometric studies that investigate associations between peer-friendship networks in adolescence (aged 11–18 years) and self-injurious thoughts and behaviors. More specifically, this study aimed to extend best practice for systematic reviews to social network studies and better understand the current landscape of research in this field. The review was guided by the research question: 'What are the findings of studies that have used sociometric social network analysis methods to investigate the association between self-injurious thoughts and behaviors and peer-friendship networks in adolescence in a school-based setting?'.

Methods

Protocol Registration

The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guideline for systematic reviews was followed (Page et al. 2021) (Online Resource 1) and the systematic review protocol was pre-registered with the International Prospective Register of Systematic Reviews (PROSPERO) (CRD42021265985).

Search Strategy

A systematic search of the literature was conducted in July 2021 to find relevant studies across five databases: EMBASE(Ovid), PsycINFO(Ovid), MEDLINE(Ovid), CINAHL and Web of Science. Search strategies included both subject headings and keywords relating to three concepts: (1) adolescence, (2) self-injurious thoughts and behaviors, and (3) social network analysis, using terms such as self-harm*, self-injur*, suicid*, social network*, peer*, adolescen*. Full search strategies can be found in Online Resource 2. Identical searches were conducted in May 2022 to check for any further papers.

Eligibility Criteria

- Studies used any kind of social network analysis and some measure of the sociometric peer-friendship network to investigate any association between peer-friendship networks and self-injurious thoughts and behaviors among adolescents.
- Studies assessed 'whole' sociometric peer-friendship networks bounded in a school setting (e.g., friendships within a class, year group, or school).
- Studies collected sociometric data using friendship nomination questions in questionnaires or name generators (e.g., nominate # of friends in your class at your school).
- Peer networks defined as 'friendships' between adolescents.
- Participants aged between 11 and 18 years of age (i.e., school-aged adolescents).
- Self-injurious thoughts and behaviors defined as any act of self-poisoning, or intentional self-injury carried out by a person, irrespective of their motivation (including non-suicidal self-injury, suicidal ideation, suicide attempt, suicide).
- Longitudinal, cross-sectional, observational, or interventional in design.
- English language.
- No year/date restriction.
- Peer reviewed.

Study Selection

After searching the databases and removing duplicate articles, the titles and abstracts of all papers were screened according to the eligibility criteria using Rayyan systematic review software (https://www.rayyan.ai/). One researcher screened the titles and abstracts (HC) with 1000 (35%) independently cross-checked by a second researcher (EW). At the full text stage, two independent reviewers screened 100% of the articles and decided the papers for final inclusion (HC, EW). Any uncertainties were discussed with a

third researcher with expertise in social network analysis (MC). Forward and backward citation searching of the articles that reached the full-text screening stage was conducted and the reference lists of similar systematic reviews were checked to identify any further articles.

Data Extraction and Risk of Bias

One researcher (HC) extracted key information from included studies into a pre-designed data extraction form and assessed each study for its risk of bias. Key extracted data included: study details (author, year, country), design, sample characteristics, sociometric procedure used, sociometric metrics assessed, self-injurious thoughts and behaviors assessed. Data extraction and risk of bias assessment for ten studies (66%) were independently cross-checked by a second researcher (EW). There is no standard tool for assessing risk of bias for network studies. Therefore, two tools used in prior social network analysis reviews were tested (Knox et al., 2019; Sabot et al. 2017). First, a 12-item tool developed by Knox et al., (2019) was used that consisted of modified sets of criteria from other established tools e.g., the Newcastle-Ottowa scale for observational studies (Lo et al. 2014) (Online Resource 3). Secondly, a 24-item tool developed by Sabot et al. (2017) was used that was informed by other established checklists such as: Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) and Critical Appraisal Skills Program (CASP) (Online Resource 4). Scores were collated into one of three 'risk of bias' categories for each paper: low (> 75%), medium (50–75%), high (< 50%) and any discrepancies between the two scales were discussed and resolved with a third researcher with expertise in social network analysis (MC).

Evidence Synthesis

Findings were collated in a narrative synthesis organized by the type of network metric measured within the studies. Some studies assessed multiple network metrics and could appear in more than one group if they separated their results. If a study measured multiple metrics and appeared under more than one subheading, characteristics about the study are provided the first time it is mentioned to give context, but this information is not repeated in subsequent sections. Due to the heterogeneity of network metrics, outcomes, and analyses used, a meta-analysis was not conducted.

Results

Searches

Searching the databases yielded 2886 de-duplicated records (Fig. 1). 2837 records were excluded based on title and abstract and the full texts of 49 potentially eligible studies were examined. Of these, 14 studies met all eligibility criteria. After conducting forward and backward citation searching of the 49 articles that went through to the full-text stage, one further eligible study was found. This culminated in 15 papers eligible for inclusion in the review. Searches were re-run in May 2022 and no new papers were identified. Researchers (HC, EW) reached > 90% agreement at all stages of screening and any uncertainties were resolved with a third researcher with expertise in social network analysis (MC).

Risk of Bias

Risk of bias was generally low, with 12 studies scoring low for risk of bias (80%), and three scoring medium for risk of bias (Table 1) (Baller and Richardson 2009; De Luca et al. 2012; Haynie et al. 2006). The same overall conclusion for risk of bias category (high, medium, low) was made for each study using two risk of bias tools (Knox et al., 2019; Sabot et al. 2017). However, the Sabot et al. (2017) tool was preferred as it captured more questions about the potential biases of network studies (Online Resource 4).

Study Characteristics

Characteristics of each study are summarized in Tables 1 and 2, and Online Resource 5. Twelve studies were from the USA (73%) and three from China (Giletta et al. 2015; You et al. 2013, 2016). Data come from seven independent studies which meant that some samples overlapped: eight studies (53%) used samples from the National Longitudinal Study of Adolescent to Adult Health (which is referred to as 'Add Health' moving forward) (Harris et al. 2019), two studies used samples from a study of eight co-educational high schools in China (You et al. 2013, 2016), and five studies (33%) used samples from other data sources of adolescents in the USA and China. Thirteen (86%) of the 15 papers were analyses of longitudinal data with follow-up times ranging from six months to two years, only two were cross-sectional (De Luca et al. 2012; Wyman et al. 2019).

Our original inclusion criteria stated 'adolescents aged 11–18' years of age. However, studies that used Add Health data analyzed adolescents from 7th -12th grade who were aged 11–19 years old at baseline, and 12–20 years old at their one-year follow up assessment. These studies were

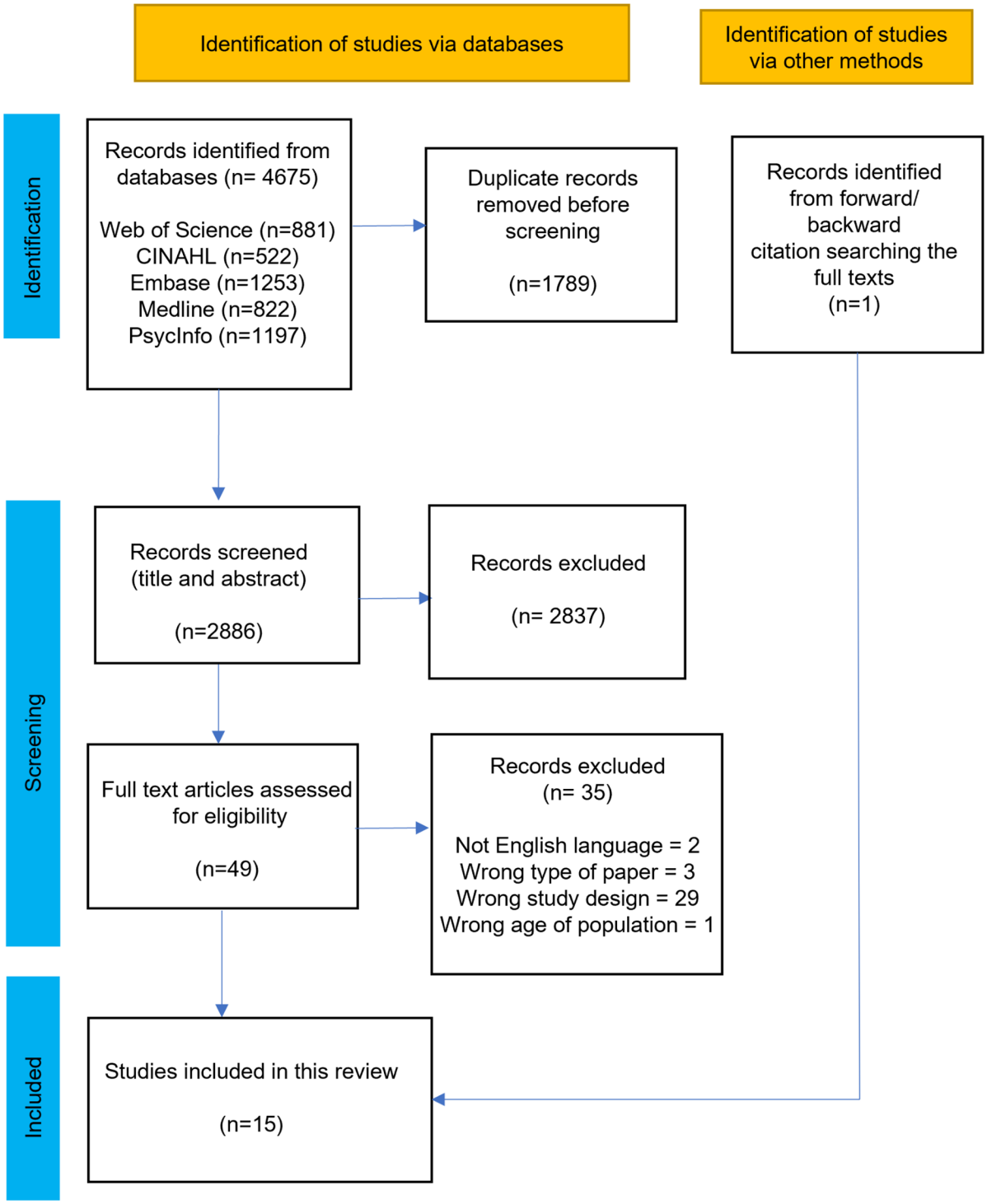

Fig 1. Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) Flow Chart of the Study Selection Process

Table 1 Summary Characteristics of Included Studies

Author, year, country	Study design	Sample characteristics	Exposure (network metric(s) assessed)	Outcome (SITBs assessed)	Analysis, measure of effect	RoB
Haynie et al. (2006), USA	Longitudinal, Add Health (2 waves, 1 year follow up)	N = 9594, age range 11–18, mean age: 14.93, SD: 1.56, grades 7–12, 132 middle/high schools, 52% girls, ethnicity (White [68%], Black [16%], Other [17%])	Isolation, Bonacich centrality, Friends' delinquency, Friends' popularity	Suicide attempts (binary, yes/no), self-reported, past 12 months	Multivariate logistic regression (*b* unstandardized coefficient, SE)	Medium
Baller and Richardson (2009), USA	Longitudinal, Add Health (2 waves, 1 year follow up)	N = 2084 (full sample), N = 1300 (at-risk subset), age range 11–18, mean age (full sample): 16.24, SD: 1.47, grades 7–12, 15 high/middle schools, 49% girls, ethnicity (White [59.7%], Hispanic or Latino [18.3%])	Intransitivity index, Number of friends with attempts, Number of friends-of-friends with attempts	Suicidal ideation (binary, yes/no), self-reported, past 12 months	Survey logistic regression models (β coefficient, SE)	Medium
Copeland et al. (2019), USA	Longitudinal, PROSPER survey (2 waves, 1 year follow up)	N = 11,160, age range 16–18, mean age NR, grades 11–12, 56% girls, ethnicity (White [86%], Other [14%])	Popularity, Sociality, Closenesscentrality, Betweenness centrality, Bonacich centrality, Reciprocity, Friends' self-harm	Self-harm (self-cutting, yes/no), self-reported, (past 12 months)	Multi-level logistic regression (β coefficient, SE)	Low
Bearman and Moody (2004), USA	Longitudinal, Add Health (2 waves, 1 year follow up)	N = 13,465, age range 11–18, mean age: 15.82, SD: 1.75, grades 7–12, 50% girls, ethnicity (White [61%], Black [14%], Other/mixed [25%],	Isolation, Intransitivity index, Density	Suicidal ideation (binary yes/no) and suicide attempts (binary yes/no), self-reported, past 12-months	Logistic regression (ORs, 95%CI)	Low
De Luca et al. (2012), USA	Cross-sectional, Add Health (1 wave)	N = 1,618, age range 12–19, mean age 15.0, SD NR, 100% girls, ethnicity (Latina [100%])	Reciprocity	Suicidal ideation (binary yes/no) and suicide attempts (frequency), self-reported, past 12-months	Logistic regression for ideation, Negative binomial regression for attempts	Medium
Giletta et al. (2013), USA	Longitudinal, 4 waves (6-month intervals)	N = 348, 3 high-schools, age range 14–18, mean age: 15.02, SD: 0.53, 55% girls, ethnicity (White [48.7%], African American [23.8%], Latino American [19.1%], Other [8.4%])	Friends' self-harm, Friends' depression, Friends' impulsivity	Self-harm (NSSI, frequency), self-reported, past 6-months	Stochastic actor-oriented models (SAOM), (Parameter estimates for SAOM and ORs)	Low
Giletta et al. (2015), China	Longitudinal, 8 waves (every 3 months, 2 years of follow-up)	N = 565, 2 schools, age range 16–18, mean age: 16.03, SD: 0.52, 51.7% girls	Type of reciprocal friend (no reciprocal friends, reciprocal friends who engage in self-harm, reciprocal friends who did not engage in self-harm)	Self-harm (NSSI frequency, Prinstein et al. (2008), measure) Suicidal Ideation (frequency, measures: SIQ, NIMH DISC-IV) Self-reported, past 3-months	Multinomial logistic regression (ORs and 95%CI), Trajectory modelling	Low
Ali et al. (2011), USA	Longitudinal, Add Health (2 waves, 1 year follow up)	N = 2209, age range 11–19, mean age: 16.21, SD: 1.64, 52% girls, ethnicity (White [62%], Black [22%], Hispanic [17%], Asian [7%], Other [2%])	Friends' ideation and attempts (% of friends who report ideation and attempts)	Suicidal ideation (binary, yes/no) and attempts (binary, yes/no), self-reported, past 12-months	Multivariate marginal effect probit regression models (β, SE) using contemporaneous and lagged peer measures	Low
Mueller and Abrutyn (2015), USA	Longitudinal, Add Health (2 waves, 1 year follow up)	N = 13,482, age range 11–18, mean age:15.582, grades 7–12, 51% girls, ethnicity (White [52%], African American [21%], Latina [16%], Other [2%])	Friends' undisclosed attempts, Friends' ideation, Friends' emotional distress	Suicidal ideation (binary, yes/no) and attempts (binary, yes/no), self-reported, past 12-months	Logistic regression (ORs and 95%CI)	Low

Table 1 (continued)

Author, year, country	Study design	Sample characteristics	Exposure (network metric(s) assessed)	Outcome (SITBs assessed)	Analysis, measure of effect	RoB
Prinstein et al. (2010), USA	Study 1 Longitudinal, (2 waves, 1 year follow up)	N = 377, 1 middle school, age range 11–14, mean age NR, grades 6–8 at baseline, 50% girls, ethnicity (White [86%], Asian American [4%], Latino American [2%], African American [1%], mixed [6%])	Best friends' self-harm (NSSI)	Self-harm (NSSI frequency), self-reported, past 12 months	Hierarchical multiple regression (β coefficient, b unstandardized, SE)	Low
Wyman et al. (2019), USA	Cross-sectional	N = 10,291, 38 high schools, age range 15–19, mean age NR, grades 9–12, 48.9% girls, ethnicity (White [79%], Black [8%], native American [4%], mixed race [5.3%], Hispanic [6.5%])	Isolation, Percentage of isolates, Mean # of friendship ties, Sociality, Popularity, Coreness, Out-degree centralization, In-degree centralization, Coreness centralization, Density, Transitivity, Popularity of friends with SITBs, Homophily for SITBs (clustering), Exposure to direct friends' SITBs	Suicidal ideation (binary yes/no, and rate) and attempts (binary yes/no, and rate), self-reported (Youth Risk Behavior Survey), past 12 months	Individual level analysis: mixed-effects logistic regression (ORs, 95%CI) School level analysis: linear regression (β, SE - where β is a standardized coefficient (change in rate for a 1 SD change in predictor per 100 students)	Low
Xiao and Lindsey (2021), USA	Longitudinal, Add Health (2 waves), 1 year follow up	N = 9421, age range 11–19, mean age: 15.30, SD NR, grades 7–12, 54.6% girls, ethnicity (White [56.49%], Black [20.51%), Hispanic [15.38%], Asian [6.34%], Native American [0.78%], Other races [0.37%], multi-racial [0.14%])	Peer-network size, Peer-network density	Suicidal ideation (binary, yes/no) and Suicide attempt (binary, none/1 or more times), self-reported, past 12 months	Multivariate logistic regression (ORs, 95%CI)	Low
You et al. (2016), China	Longitudinal, (2 waves, 6-month interval)	N = 1701, 8 co-educational high schools, age range 12–18, mean age: 15.06, SD:1.47, grades 7–11, 67% girls	Reciprocal friendship groups' self-harm and impulsivity (negative urgency and premeditation)	Self-harm (NSSI frequency), self-reported, past 6 months	Hierarchical linear modelling (β coefficient, SE)	Low
You et al. (2013), China	Longitudinal, (2 waves, 6-month interval)	N = 5787, 8 co-educational high schools, age range 12–19, mean age: 14.63, SD: 1.25, grades 7–11, 54.2% girls	Reciprocal best friends' self-harm (self-harm status and frequency), Reciprocal friendship groups' self-harm (self-harm status and frequency)	Self-harm (NSSI status yes/no and frequency), self-reported, past 6 months	Cross-lag multiple logistic regression (ORs, 95%CI) and hierarchical linear regression (b unstandardized, β standardized, SE)	Low
Zimmerman et al. (2016), USA	Longitudinal, Add Health (2 waves, 1 year follow-up)	N = 2180, 2 schools, age range 14–20, mean age: 17.2, SD: 1.1, 47.7% girls, ethnicity (White [45.0%, African American [12.4%], Asian [21.8%], Other [20.8%])	Accurately perceiving friends' attempts, underestimation of friends' attempts, overestimation of friends' attempts	Suicide attempts (binary, yes/no), self-reported, past 12 months	Penalized logistic regression (ORs, 95%CI)	Low

Acronyms: Self-injurious thoughts and behaviors (SITBs), Socioeconomic Status (SES), Not reported (NR), Non-suicidal Self Injury (NSSI), Suicidal Ideation Questionnaire (SIQ), National Institute of Mental Health Diagnostic Interview Schedule for Children Version IV (NIMH DISC-IV), Risk of Bias (RoB). Only details about sociometric variables are in this table. Some studies measured *non-sociometric* measures of exposure to friends' SITBs (e.g., peer norm measures), this is noted in Online Resource 5

still eligible to be included because they analyzed the sociometric friendship networks of adolescents in a school-based setting. Overall, most studies (n = 9) had a sample of adolescents with an age range that spanned across the developmental period of adolescence (e.g., age ranges of 11–19 years of age at baseline) with mean ages of these samples at baseline ranging from 14.93 to 16.21. One study focused on a sample of younger adolescents only, with an

Table 2 Overview of the Peer-friendship Network Metrics Measured in Studies and Associations with Self-injurious Thoughts and Behaviors in Adolescence

Author and SITBs measured	Haynie et al. (2006) (SA)	Baller and Richardson (2009) (SI)	Copeland et al. (2019) (SH)	Bearman and Moody (2004) (SI, SA)	De Luca et al. (2012) (SI, SA)	Giletta et al. (2013) (SH)	Giletta et al. (2015) (SH, SI)	Ali et al. (2011) (SI, SA)	Mueller and Abrutyn (2015) (SI, SA)	Prinstein et al. (2010) (SH)	Wyman et al. (2019) (SI, SA)	Xiao and Lindsey (2021) (SI, SA)	You et al. (2016) (SH)	You et al. (2013) (SH)	Zimmerman et al. (2016) (SA)	Total
Network metric measured																
Peer-network structure																
Individual position metrics																
Centrality (Bonacich)	0		-*													2
Popularity (in-degree)			0								-					2
Sociality (out-degree)			-								-					2
Closeness centrality			0													1
Betweenness Centrality (bridging)			+													1
Isolation	+			+							0					3
Proximal-peer metrics (7)																
Intransitivity index		+		+												2
Peer-network size												0				1
Peer-network density												+				1
Coreness											-					1
Reciprocity			0		0		+									3
Network-wide metrics																
Friendship network size											0					
Popularity of students engaging in SITBs											+*					1
Mean coreness of network											-*					1
Coreness centralization											0					1
In-degree centralization											0					1
Out-degree centralization											+*					1
Network clustering (homophily for SITBs)											+*					1
Mean # of friends named in network											-*					1
Percentage of isolates in network											+					1
Density				-							-*					2
Network transitivity											-*					1
Exposure to friends' SITBs																

Table 2 (continued)

Author and SITBs measured	Haynie et al. (2006) (SA)	Baller and Richardson (2009) (SI)	Copeland et al. (2019) (SH)	Bearman and Moody (2004) (SI, SA)	De Luca et al. (2012) (SI, SA)	Giletta et al. (2013) (SH)	Giletta et al. (2015) (SH, SI)	Ali et al. (2011) (SI, SA)	Mueller and Abrutyn (2015) (SI, SA)	Prinstein et al. (2010) (SH)	Wyman et al. (2019) (SI, SA)	Xiao and Lindsey (2021) (SI, SA)	You et al. (2016) (SH)	You et al. (2013) (SH)	Zimmerman et al. (2016) (SA)	Total
Socialization and selection of direct friends' self-harm (SAOM)						0										1
Direct friends' self-harm (non-SAOM)			+							+						2
Reciprocal friends' self-harm							+						+	+		3
Direct friends' depression						+										1
Friends' impulsivity (reciprocal/direct)						+							+			2
Direct friends' ideation and attempts		+						0	0		+				+	5
Friends-of-friends' (weak ties) SITBs		+														1
Friends' delinquency	+*															1
Friends' popularity	-*															1
Underestimating friends' SITBs															0	1
Overestimating friends' SITBs															+	1
Friends' emotional distress									+*							1
Friends' undisclosed attempts									+*							1
Total	4	3	7	3	1	3	2	1	3	1	16	2	2	1	3	

Self-injurious thoughts and behaviors (SITBs), self-harm (SH), suicide attempts (SA), suicidal ideation (SI)

+ Evidence of a positive association with SITBs

- Evidence of a negative association with SITBs

0 no evidence of an association with SITBs

-* Some evidence of a negative association (in simple models but not in more complex models)

+* Some evidence of a positive association (in simple models but not in more complex models)

age range of 11–14 years old at baseline (Prinstein et al. 2010). Three studies had samples of mid-to-late aged adolescents (age ranges between 14 and 19 years old at baseline) (Giletta et al. 2013; Wyman et al. 2019; Zimmerman et al. 2016). Two studies focused on the period of later adolescence only (i.e., samples of adolescents within the age range of 16–18 only at baseline) (Copeland et al. 2019; Giletta et al. 2015).

Sample sizes ranged from 348 to 13,482 adolescents. All studies were conducted in a school setting (a mix of middle schools and high schools) and used a range of sociometric nomination procedures (e.g., nominate a maximum of five friends, nominate an unlimited number of friends). Table 1 indicates diversity for some samples in terms of demographic characteristics like race/ethnicity and gender. Eleven studies had samples with a mix of ethnic groups, but predominantly White/Caucasian (e.g., White ethnicity in these studies ranged from 45 to 86%). Three studies had samples from high schools of Chinese adolescents only (Giletta et al. 2015; You et al. 2013, 2016). One study analyzed a girl-only Latina friendship network (De Luca et al. 2012). All other studies included both boys and girls with the percentage of girls ranging from 46 to 56%.

Studies examined a range of self-injurious thoughts and behaviors including suicide attempt, suicidal ideation, non-suicidal self-injury (NSSI), and self-cutting behavior. Moving forward, suicide attempts are referred to as 'attempts,' suicidal ideation is referred to as 'ideation', NSSI and self-cutting behavior(s) are referred to collectively as 'self-harm'. In the results section only, self-injurious thoughts and behaviors are acronymized to 'SITBs' in some places. Six studies measured self-harm, eight studies measured ideation, and eight studies measured attempts.

Peer-network Metrics

Studies assessed multiple network metrics (Tables 2 and 3). To facilitate the synthesis, metrics were grouped in two ways: (1) peer-network structure (i.e., individual position, proximal-peer, network-wide metrics) (2) exposure to friends' self-injurious thoughts and behaviors (including dynamic processes like socialization and/or selection). Definitions of structural network metrics are provided in Table 3.

Study Analyses

Studies used a range of analytical techniques (e.g., different forms of linear, logistic, probit, and lagged regression). One study used a Stochastic Actor-Oriented Model (SAOM), and the results of this study are presented under a separate heading within the 'exposure to friends' self-injurious thoughts and behaviors' section because of the model's unique ability to tease apart the dynamic processes of socialization and selection compared with other analytical models. Only the SAOM-based study was considered as measuring socialization and selection, all other 'non-SAOM' studies that measured exposure to friends' self-injurious thoughts and behaviors were grouped into a separate category (even if they used the phrases socialization and selection in their paper). Statistical models included a range of covariates including sociodemographic characteristics, depressive symptoms, impulsivity, bullying, connection to the school, peer support, and family suicidality (Online Resource 5).

Eleven studies set out to test gender differences (two studies split their analyses by gender, nine studies assessed gender as an interaction or moderating term within their analyses). Although studies had samples of adolescents from across the range of adolescence, only one study that focused on early adolescence (grades 6–8, ages 11–14) assessed age as an interaction term in their analyses (Prinstein et al. 2010), all other studies either adjusted for age or did not adjust for age due to low variability across the sample (Wyman et al. 2019).

Despite diversity in some samples for demographic characteristics like ethnicity/race, only one study explicitly looked at ethnicity/race as a moderating term within their analyses (Xiao and Lindsey, 2021). One study included an effect for ethnicity in their SAOM model to look at the tendency for same-ethnicity youth to select same-ethnicity friends, but this was not assessed in relation to self-injurious thoughts and behaviors (Giletta et al. 2013). All other studies with diversity in terms of race/ethnicity adjusted for ethnicity in their analyses. Some studies also adjusted for same-sex attraction, but only one study specifically looked at sexual identity as a moderating term in their analyses (Xiao and Lindsey, 2021). One study measured network metrics within a full sample of adolescents and an 'at-risk' subset (i.e., where risk was a function of heavy drinking, fighting, rape victimization, same-sex attraction, and obesity) (Baller and Richardson 2009), and one study assessed if network metrics mediated the effect of residential mobility (i.e., moving within the last two years) on self-injurious thoughts and behaviors among adolescents (Haynie et al. 2006).

Effect sizes from the respective studies' preferred statistical models are reported below, but details about what the models adjusted for are available in Online Resource 5. For studies that used linear regression, they reported standardized (β) and/or unstandardized beta coefficients (b), standard error (SE) and/or 95% confidence intervals (95%CI). For studies that used logistic regression, some reported only the standardized (β) or unstandardized (b) beta coefficients

Table 3 Structural Peer-network Metric Definitions

Name	Definition
Peer-network structure	
Individual position metrics	
Centrality (Bonacich)	a measure of one's popularity in a network taking into the account the popularity of one's own friends
Closeness Centrality	a measure of how easily one can access others in a network measured by how many steps one would need to take to reach others
Betweenness Centrality	high values indicate that an adolescent connects other peers in the network
Popularity (in-degree)	how many friendship nominations one receives
Sociality (out-degree)	how many nominations a respondent sends
Isolation	adolescent who neither sends nor receives any nominations
Proximal-peer metrics	
Intransitivity index	a measure of the proportion of an individual's friends' friends who were not also the individual's friends
Coreness	size of friendship group based on one's own and immediate friends' nominations
Peer-network density & size	using the ego-centered network of an individual, density is calculated as the ratio of actual friendship ties among participants in the nominated ego-centered networks to all possible ties
Reciprocity	a measure of friends' closeness. It is a measure of whether nodes in a directed network are mutually linked i.e., if one node nominated a friend, and that friend nominates back they are reciprocal
Network-wide metrics	
Network Density	a measure of the ratio of actual friendship ties among participants in the network to all possible ties. When all possible ties exist, this value is 100
Coreness centralization	degree to which there is one distinct core of individuals disconnected from others. When there is one core of connected individuals, this value is 100
In-degree centralization	degree to which incoming nominations are concentrated in a few, popular students. When all ties are directed to only one student, this value is 100
Out-degree centralization	degree to which outgoing nominations are concentrated in a few students. When all ties originate from only one student, this value is 100. Having a high out-degree centralized network would mean friendship nominations were disproportionately concentrated in fewer students
Percentage of isolates	percentage of students who neither name friends nor are named by others
Mean # of friendships	average total friendship nominations for students in the network. When aggregated, average in-degree equals average out-degree
Clustering of students with SITBs/homophily for SITBs	a measure of the degree to which suicidal students are connected to each other, calculated by Moran's *I*. When students are completely segregated by suicide/self-harm status (complete homophily), this value is 1
Popularity of students that engage in SITBs	the average in-degree for students with either suicidal ideation or attempts divided by the in-degree for students with neither. When suicidal and non-suicidal students are equally popular, this value is 1 (Wyman et al. 2019)
Network transitivity	degree to which triads in the network form triangular closure (closure happens when a student's friends are also friends with each other). When all triads are closed, this value is 100
Exposure to friends' SITBs	
Best-friend reciprocated dyad	both persons identify each other as the first best friend
Reciprocated friendship group	all members in a friendship group identify each other as friends, e.g., "*where adolescents belonged to a reciprocated peer group of at least three persons"* (You et al. 2013, 2016)

Self–injurious thoughts and behaviors (SITBs). Node: a point that in a network or sociogram at which lines or pathways intersect or branch. In sociometric studies of school–based friendship networks, a node refers to an individual student within the school network. Ego–network: maps the connections of and from the perspective of a single person in the network

and SE, and others reported odds ratios (OR) and 95% CI's. Statistics are reported as they were presented in the paper.

Peer-network Structure

Individual Position Metrics

Four studies measured a range of individual positions within a peer-friendship network and their association with

self-injurious thoughts and behaviors (Bearman and Moody 2004; Copeland et al. 2019; Haynie et al. 2006; Wyman et al. 2019). Overall, there was evidence that higher sociality (i.e., how many friendship nominations one sends) was negatively associated with self-injurious thoughts and behaviors, but limited evidence or mixed findings for all other position metrics.

Bonacich Centrality

Two longitudinal studies measured Bonacich centrality (i.e., being popular among peers that are also popular across the network) and findings were mixed (Copeland et al. 2019; Haynie et al. 2006). Specifically, one study analyzed a sample of 11,160 adolescents from US high schools and found that Bonacich centrality was negatively associated with self-harm (β: -0.366, SE:0.12) in a simple model adjusted for depressive symptoms and sociodemographic characteristics (Copeland et al. 2019). However, the effect was reduced and no longer independently associated with self-harm in a more complex model with other network facets included (to better understand the simultaneity of network effects) (β: -0.268, SE:0.25). Conversely, a different study analyzed a sample of 9594 adolescents from Add Health assessing multiple network metrics (including Bonacich centrality) as potential mediators on the effect of being a residential mover and attempts among adolescents (Haynie et al. 2006). They found no evidence that Bonacich centrality was associated with attempts among girls (b: 0.111, SE: 0.174) or boys (b: -0.268, SE: 0.296).

Closeness and Betweenness Centrality

Only one study measured these metrics (Copeland et al. 2019). Longitudinally, they found that betweenness centrality (i.e., higher values indicate adolescents that bridge others in a network) was positively associated with self-harm among adolescents (β: 2.316, SE: 0.79) but no evidence that closeness centrality (a measure of how easily one can access others in a network) was associated with self-harm (β: -1.063, SE: 1.11).

Popularity (in-degree)

Two studies measured popularity (i.e., how many friendship nominations one receives) and findings were mixed (Copeland et al. 2019; Wyman et al. 2019). Cross-sectionally, one study analyzed the friendship networks of 10,291 adolescents from 38 US high-schools and found evidence of a negative association between popularity and attempts [vs no SITBs] (OR: 0.95, 95% CI: 0.92, 0.98), ideation [vs no SITBs] (OR: 0.95, 95% CI: 0.92, 0.97), and attempts [vs. ideation] (OR: 0.98, CI: 0.94, 1.02) in models adjusted for sex, age, and ethnicity (Wyman et al. 2019). Longitudinally, a different study found no evidence that popularity was associated with self-harm among adolescents (β: 0.047, SE: 0.06) (Copeland et al. 2019).

Sociality (out-degree)

Two studies measured this metric, and both found evidence that sociality (i.e., how many friendship nominations one sends) was associated with lower self-injurious thoughts and behaviors (Copeland et al. 2019; Wyman et al. 2019). Longitudinally, one study found that sociality was negatively associated with self-harm among adolescents (β: -0.167, SE: 0.05) and this effect was stronger among boys (Male X Sociality β: -0.269, SE: 0.11) (Copeland et al. 2019). Cross-sectionally, a different study found that sociality was negatively associated with attempts [vs no SITBs] (OR: 0.87, 95%CI: 0.85, 0.90), ideation [vs no SITBs] (OR: 0.93, 95% CI: 0.91, 0.96) and for ideation [vs attempts] (OR: 0.92, 95%CI: 0.88, 0.96) among adolescents in models adjusted for sex, age, and ethnicity (Wyman et al. 2019). The effect for sociality was stronger among girls for ideation [vs no SITBs] (OR: 0.89, 95%CI: 0.85, 0.92) compared with boys (OR: 0.97, 95%CI: 0.93, 1.01).

Isolation

There were mixed findings for isolation: three studies (two longitudinal, one-cross-sectional) measured this metric, two of which found evidence that being isolated (i.e., neither sending nor receiving any nominations) was associated with higher self-injurious thoughts and behavior (both using Add Health samples) but with gender differences (Bearman and Moody 2004; Haynie et al. 2006; Wyman et al. 2019). Longitudinally, one study analyzed the friendship networks of 13,465 adolescents from Add Health and found that isolation (vs. not) was positively associated with ideation (but not attempts) among girls (OR: 2.010, 95%CI: 1.073, 3.765) in models adjusted for sociodemographic characteristics (Bearman and Moody 2004). In boys, they found no evidence isolation was associated with ideation (OR: 0.665, 95%CI: 0.307, 1.445) or attempts (OR: 0.767, 95%CI: 0.159, 3.707). A different study analyzed a sample of 9594 adolescents from Add Health and found evidence that isolation (vs. not) was positively associated with attempts among girls (β: 0.700, SE: 0.345), but no evidence it was associated with attempts among boys (β: 0.458, SE:0.539) (Haynie et al. 2006). A cross-sectional study found no evidence of an association between isolation (vs. not) and attempts [vs no SITBs] (OR: 1.22, 95%CI: 0.74, 1.99), ideation [vs no SITBs] (OR: 1.25, 95%CI: 0.79, 1.97) or for attempts [vs.

ideation] (OR: 1.64, 95%CI: 0.75, 3.61) among adolescents from a different sample of US High schools (Wyman et al. 2019).

Proximal-peer Metrics

Seven studies measured proximal-peer metrics (i.e., features of an adolescent's immediate peer-group within the larger network) and their association with self-injurious thoughts and behaviors among adolescents (Baller and Richardson 2009; Bearman and Moody 2004; Copeland et al. 2019; De Luca et al. 2012; Giletta et al. 2015; Wyman et al. 2019; Xiao and Lindsey 2021). There was evidence that the intransitivity index was positively associated with self-injurious thoughts and behaviors, but limited evidence or mixed findings for all other proximal-peer metrics.

Intransitivity Index

Two longitudinal studies (using samples from Add Health) measured the intransitivity index (i.e., a measure of the proportion of an adolescent's friends' friends who were not also the adolescent's friend) and both found that scoring higher on this index was positively associated with self-injurious thoughts and behaviors among adolescents (Baller and Richardson 2009; Bearman and Moody 2004). Specifically, one study found the index was positively associated with ideation among their whole sample of adolescents (n = 2084, β: 1.208, SE: 0.342) and among an at-risk subset (n = 1300, β: 1.246, SE: 0.621) (Baller and Richardson 2009). A different study found the index was positively associated with ideation (but not attempts) among girls (OR: 2.198, 95%CI: 1.221–3.956) but no evidence it was associated with ideation or attempts among boys (Bearman and Moody 2004).

Coreness

Only one study measured this metric (i.e., size of friendship group based on one's own and immediate friendship nominations) (Wyman et al. 2019). Cross-sectionally, they found that coreness was negatively associated with attempts [vs no SITBs] (OR: 0.84, 95%CI: 0.80, 0.87), ideation [vs no SITBs] (OR: 0.90, 95%CI: 0.86, 0.93), and attempts [vs. ideation] (OR: 0.89, 95% CI: 0.84, 0.95) among adolescents in models adjusted for sex, age, and ethnicity. For ideation, the effect was stronger among girls (OR: 0.83, 95%CI: 0.79, 0.87) compared with boys (OR: 0.95, 95%CI: 0.89, 1.00).

Peer-network Density and Size

Only one study measured these metrics (i.e., measures of the number of connections within an adolescent's immediate friend group) and associations with belonging to trajectory classes of ideation and attempts among a sample of 9421 adolescents from Add Health (Xiao and Lindsey 2021). Longitudinally, they found no evidence of an association between these metrics and belonging to trajectory classes of attempts. However, in supplementary moderator analyses looking at race/ethnicity and sexual identity, they found that sexual minority youth were more likely to be in a 'high-decreasing' ideation trajectory compared with a 'low stable' ideation trajectory when having a densely connected peer-network (OR 1.19, 95% CI 1.02–1.40). They found no strong evidence for ethnicity as a moderator of these effects.

Reciprocity

There were mixed findings for reciprocity and self-injurious thoughts and behaviors. Of the three studies that measured reciprocity (two longitudinal, one cross-sectional), two found no evidence of an association with self-injurious thoughts and behaviors (Copeland et al. 2019; De Luca et al. 2012) and one found evidence that a lack of reciprocal friends (vs. having friends with/without self-harm) was associated with being in a moderate compared with low self-harm trajectory (Giletta et al. 2015)[1]. Specifically, one study analyzed the friendship networks of 565 adolescents from two schools in China. They assessed whether having no reciprocal friends compared with having reciprocal friends (with and without self-harm) was associated with belonging to latent trajectory groups of self-harm and/or ideation (low, moderate, high). After adjusting for gender and depressive symptoms they found that adolescents were less likely to be in the moderate trajectory group for self-harm (compared with low) if they had reciprocal friends who self-harm (OR: 0.46, 95%CI: 0.21, 1.00) or reciprocal friends who did not self-harm (OR: 0.35, 95%CI: 0.16, 0.76) compared with having no reciprocal friends at all. No friendship type effects were found for ideation trajectory groups (Giletta et al. 2015). Conversely, a different study measured the mere presence of reciprocity (i.e., the proportion of adolescent's ties in which both parties nominated each other) and found no evidence of an association with self-harm among adolescents (β: 0.030, SE: 0.22) (Copeland et al. 2019). Cross-sectionally, another study analyzed a Latina only friendship network (n = 1618) from Add Health and found no evidence of an association between reciprocity and attempts or ideation (statistics not reported) (De Luca et al. 2012).

[1] Giletta et al. (2015) measured '*reciprocal friends' self-harm*' but found that structure was more impactful than friends' behavior, as explained here. Therefore, the results of this study are only presented in this structural section, not in the '*exposure to reciprocal friends' self-harm*' section.

Network-wide Metrics

Network-wide refers to measuring the way an *entire* school functions (e.g., a climate or context related to self-injurious thoughts and behaviors) compared with structural positions or proximal-peer metrics. Two studies measured network-wide density (Bearman and Moody 2004; Wyman et al. 2019) and only one study measured a range of network-wide metrics and associations with self-injurious thoughts and behaviors (Wyman et al. 2019). There was more evidence that density (i.e., belonging to an overall dense school friendship network) was negatively associated with self-injurious thoughts and behaviors, but limited evidence for all other network-wide metrics. Overall, these two studies provide evidence that peers relate to self-injurious thoughts and behaviors not just through characteristics of direct friends or structural positions among direct friends, but the overall patterns of networks in the school relate to overall rates of self-injurious thoughts and behaviors.

Density

Two studies measured density (i.e., a measure of the ratio of actual friendship ties among adolescents in the network to all possible ties) and found that schools with higher density were associated with lower self-injurious thoughts and behaviors (Bearman and Moody 2004; Wyman et al. 2019). Longitudinally, one study found evidence that for girls, density was negatively associated with ideation (OR: 0.333, 95%CI: 0.142, 0.783) but not for attempts. For boys, there was no evidence density was associated with ideation (OR: 1.061, 95%CI: 0.375, 2.999), but they found evidence it was negatively associated with attempts [among boys with past year ideation] (OR: 0.049, 95%CI: 0.005, 0.521) (Bearman and Moody 2004). Cross-sectionally, one study found that density was negatively associated with rates of ideation [vs no SITBs] (β: -1.61, 95%CI: -2.61, -0.61) in a simple model adjusted for network size, sex, and ethnicity, but this effect was reduced and no longer independently associated in a more complex model with other similar network facets included (β: -0.82, 95%CI: -6.06, 4.41). They found no evidence of an association with rates of attempts in any models (Wyman et al. 2019).

Other Network-wide Metrics

Only one cross-sectional study measured a further range of network-wide metrics that they taxonomized to encompass peer-network *integration* (e.g., mean coreness, percentage of isolates, mean number of friendship ties), *cohesion* (e.g., transitivity, density), *centralization* (e.g., out-degree, in-degree, coreness centralization), *peer influence* (e.g., popularity of peers that engage in SITBs) and *clustering of students with self-injurious thoughts and behaviors* (e.g., homophily for SITBs) (Wyman et al. 2019). They assessed whether each metric was associated with rates of ideation [vs no SITBs], attempts [vs no SITBs], and attempts [vs ideation] among adolescents in simple models adjusted for network size, sex, and ethnicity and in more complex models including other network facets. Most network-wide metrics were only associated with self-injurious thoughts and behaviors in simple models, few remained independently associated in more complex models.

Specifically, in simple models they found that rates of ideation [vs no SITBs] were higher in schools with a higher percentage of isolates (β: 1.08, 95%CI: 0.03, 2.13) and lower in schools with students naming more friends (β: -1.23, 95%CI: -2.22, -0.24), higher mean coreness (β: -1.60, 95%CI: -2.59, -0.61), and higher transitivity (β: -1.66, 95%CI: -2.98, -0.35). However, in a more complex model the effect for coreness was attenuated and no longer independently associated.

They found that rates of attempts [vs no SITBs] were higher in schools where peers that engaged in SITBs were more popular (i.e., the average in-degree for adolescents with SITBs divided by the in-degree for adolescent's without SITBs) in both a simple (β: 1.20, 95%CI: 0.25, 2.14) and more complex model (β: 0.93, 95%CI: 0.10, 1.77), though it was attenuated in a sensitivity analysis that adjusted for bullying (β: 0.68, 95%CI: -0.31, 1.68). In simple models they also found that rates were higher in schools where out-degree centralization was higher (i.e., the degree to which outgoing nominations are clustered in a few students) [β: 2.36, 95%CI: 0.35, 4.36] and where students with SITBs were overall more clustered in the network (homophily for SITBs) [β: 1.31, 95%CI: 0.49, 2.13] and that rates were lower in schools where students named more friends (β: -1.35, 95%CI: -2.34, -0.36), and where network transitivity was higher (β: -1.85, 95%CI: -3.17, -0.54). However, in more complex models, the effects for all these metrics were attenuated and were no longer independently associated with rates of attempts.

For rates of attempts [vs ideation], in simple models they found that rates were higher in schools where peers that engaged in SITBs were more popular (β: 5.60, 95%CI: 1.28, 9.92) and where students with SITBs were more clustered in the network (β: 4.15, 95%CI: 0.09, 8.21). They also found rates were lower in schools where network transitivity was higher (β: -6.41, 95%CI: -12.74, -0.07). However, in more complex models the effects for all metrics were attenuated and no longer independently associated with rates of attempts.

Exposure to Friends' Self-injurious Thoughts and Behaviors

Twelve studies measured metrics that fit in this category (Ali et al. 2011; Baller and Richardson 2009; Copeland et al. 2019; Giletta et al. 2013, 2015; Haynie et al. 2006; Mueller and Abrutyn 2015; Prinstein et al. 2010; Wyman et al. 2019; You et al. 2013, 2016; Zimmerman et al. 2016). There was more evidence that having friends who report self-harm was associated with an adolescent's own self-harm but mixed findings for associations between friends' report of ideation and attempts and an adolescent's own ideation and attempts. There was a lack of evidence for socialization and selection of self-harm due to only one study using a SAOM.

Socialization and Selection of Self-harm (SAOM)

Only one study used a SAOM to disentangle socialization and selection processes and found evidence for *indirect* socialization (i.e., a behavior is influenced by a related behavior) of self-harm via depressive symptoms, but no evidence of direct socialization or selection of self-harm (Giletta et al. 2013). Specifically, they analyzed the friendship networks of 348 adolescents over four assessment waves (6-month intervals). They found adolescents whose friends reported higher depressive symptoms were more likely to increase (and less likely to decrease) their self-harm as compared to adolescents with friends reporting lower depressive symptoms (β: 0.50, SE: 0.21). There was an interaction between gender and friends' impulsivity. Friends' impulsivity did not affect changes in self-harm among girls, however the odds ratio of increasing self-harm compared with no change increased from 0.6 for males whose friends reported low impulsivity to 1.2 for males with highly impulsive friends.

Reciprocal Friends' Self-harm

Two longitudinal studies measured reciprocal friends' self-harm (both using samples from the same co-educational schools in China) and found that it was associated with adolescents' own self-harm (You et al. 2013, 2016). Specifically, one study analyzed a sample of 5787 adolescents assessing self-harm frequency and self-harm status among reciprocal best-friend dyads and reciprocal friendship groups (You et al. 2013). After adjusting for depressive symptoms and impulsivity, they found that both reciprocal best friends' and reciprocal friendship groups' self-harm at Time 1 (T1) was positively associated with adolescents' subsequent self-harm 6-months later [T2] (e.g., Adolescents' T2 self-harm status on best friends' self-harm status at T1 [β: 0.44, SE: 0.17, (OR: 1.56, 95%CI: 1.12, 2.17)], adolescents' T2 self-harm frequency on friendship groups' self-harm status at T1 [b: 0.20, SE: 0.10, β: 0.05, t: 1.98]). Bi-directionally, they also found that adolescents' self-harm at T1 was positively associated with their friendship groups' self-harm at T2 (e.g., Friendship groups' self-harm status at T2 on adolescents' self-harm status at T1 [β: 1.14, SE: 0.38, [OR: 3.12, 95%CI: 1.50, 6.50]). Similarly, a different study analyzed a sample of 1701 adolescents but measured only reciprocal friendship groups' self-harm (You et al. 2016). They found evidence that friendship groups' self-harm frequency at T1 was positively associated with adolescents' subsequent self-harm frequency at T2 (b: 0.0178, SE: 0.0014), but additionally found that friendship groups' impulsivity was associated with adolescents' self-harm frequency at T2 (b: 0.0007, SE: 0.0003).

Direct Friends' Self-harm (non-SAOM)

Two longitudinal studies measured friends' self-harm (regardless of reciprocity) and both found that it was positively associated with adolescents' own self-harm (Copeland et al. 2019; Prinstein et al. 2010). Specifically, one study analyzed the networks of 377 adolescents in grades 6–8 at one school in the USA (Prinstein et al. 2010). They found that best friends' self-harm frequency at time 1 (T1) was longitudinally associated with adolescents' self-harm frequency one year later (T2), although gender and grade were significant moderators. There was evidence that for girls only, best friends' self-harm frequency at T1 was positively associated with adolescents' subsequent self-harm frequency at T2 (b: 0.03, SE: 0.01 [β: 0.21]) and this was evident among sixth grade students (b: 0.18, SE: 0.06 [β: 0.29]), but not seventh or eighth grade students. Similarly, a different study found that having direct friends who report self-harm (binary yes/no) was positively associated with adolescents' self-harm status (β: 1.341, SE: 0.34) (Copeland et al. 2019).

Exposure to Friends' Ideation and Attempts

There were mixed findings for exposure to ideation and/or attempts among friends. Five studies (one cross-sectional, four longitudinal using samples from Add Health) measured metrics within this category (i.e., friends' reports of ideation and attempts), and three found evidence of positive associations with adolescents' self-injurious thoughts and behaviors (Ali et al. 2011; Baller and Richardson 2009; Mueller and Abrutyn 2015; Wyman et al. 2019; Zimmerman et al. 2016).

Cross-sectionally, one study measured the proportion of adolescents' friends with ideation and attempts and found that having a higher proportion of friends with self-injurious thoughts and behaviors was positively associated with

adolescents' self-injurious thoughts and behaviors (Wyman et al. 2019). Specifically, number of friends with ideation was positively associated with adolescents' ideation [vs no SITBs] (OR: 1.30, 95%CI: 1.16, 1.45) and attempts [vs no SITBs] (OR: 1.28, 95%CI: 1.13, 1.46). Similarly, number of friends with attempts was positively associated with adolescents' ideation [vs no SITBs] (OR: 1.49, 95%CI: 1.33, 1.67), attempts [vs no SITBs] (OR: 1.96, 95%CI: 1.76, 2.19) and attempts [vs ideation], with the effect for attempts [vs ideation] being stronger among girls (OR: 1.64, 95%CI: 1.13) compared with boys (OR:1.13, 95%CI: 0.87, 1.48).

Longitudinally, four studies analyzed samples from Add Health, and two found positive associations between friends' reported ideation and/or attempts and adolescents' ideation and attempts. One study found that number of friends with attempts was positively associated with adolescents' ideation (β: 0.628, SE: 0.183) and when further analyzing an at-risk sample of adolescents the number of friends-of-friends with attempts was also positively associated with adolescents' ideation (β: 0.140. SE: 0.037), but the effect was stronger among direct friends (β: 0.913, SE: 0.268) (Baller and Richardson 2009). Another study analyzed a sample of 2180 adolescents and found that accurately perceiving friends' reported attempts was positively associated with adolescents' attempts (OR: 2.54, 95%CI: 1.06, 6.10) (Zimmerman et al. 2016). Conversely, one study analyzed a sample of 13,482 adolescents and found no evidence of an association between being exposed to friends' ideation (vs. not) and adolescents' subsequent ideation (OR: 1.047, 95%CI: 0.868, 1.263) or attempts (OR: 1.107, 95%CI: 0.805, 1.523) although they found that reporting a friend dying of suicide (non-sociometric variable) was positively associated with adolescents' SITBs (ideation [OR: 1.471, 95%CI: 1.095, 1.977] attempts [OR: 2.604, 95%CI: 1.633, 4.151]) (Mueller and Abrutyn 2015). Similarly, another study measured a sample of 2209 adolescents and found no evidence that exposure to friends' SITBs (measured as 'percentage of friends with ideation and attempts') was associated with adolescents' subsequent ideation or attempts in their preferred lagged regression models (Ali et al. 2011).

Friends' Undisclosed Attempts and Emotional Distress

Only one longitudinal study measured friends' undisclosed attempts (i.e., a binary measure of inaccurately reporting that a friend did not attempt suicide when the friend did report this) and friends' emotional distress (i.e., higher mean score is equal to higher distress) and associations with adolescents' own ideation and attempts (Mueller and Abrutyn, 2015). They found in simple models (without adolescents' characteristics included) that friends' undisclosed attempts (OR: 1.354, 95%CI: 1.030, 1.780) and friends' emotional distress (OR: 1.210, 95%CI: 1.032, 1.420) were positively associated with adolescents' ideation. However, in more complex models adjusting for adolescents' characteristics, the effect for friends' undisclosed attempts (OR: 1.095, 95%CI: 0.813, 1.473) and friends' emotional distress (OR: 1.004, 95%CI: 0.832, 1.212) were attenuated and no longer independently associated with ideation among adolescents. Only friends' emotional distress was associated with adolescents' attempts in a simple model (OR: 1.372, 95%CI:1.033, 1.823) but this effect was attenuated and no longer independently associated in a more complex model.

Misperception of Friends' Attempts Self-injurious Thoughts and Behaviors

Only one longitudinal study measured these metrics (Zimmerman et al. 2016). They found that overestimating friends' attempts (i.e. adolescent reported that at least one friend attempted suicide, whereas no friends self-reported an attempt) was positively associated with adolescents' own attempts (OR: 5.40, 95%CI: 3.34, 8.77), but no evidence that underestimating (i.e., adolescent reported that no friends attempted suicide, whereas at least one friend self-reported an attempt) was associated with attempts (OR: 1.31, 95%CI: 0.61, 2.79).

Friends' Popularity and Delinquency

Only one longitudinal study measured these metrics (Haynie et al. 2006). They found that having friends report higher participation in delinquent activities was positively associated with attempts among girls (*b*: 0.068, SE: 0.032) and having friends who are popular was negatively associated with attempts among girls (*b*: -0.062, SE: 0.031). However, in a more complex model adjusted for sociodemographic characteristics and other network metrics the effects for friends' delinquency (*b*: 0.027, SE: 0.041) and popularity (*b*: -0.052, SE: 0.048) were attenuated and no longer independently associated with attempts. There was no evidence either metric was associated with attempts among boys.

Discussion

Self-injurious thoughts and behaviors are a major health challenge among adolescents. Adolescence is a developmental period in which peers, particularly in-school peers, play a socially salient role. Peers are influential for externalizing health behaviors (e.g., alcohol consumption) but how in-school peers might be associated with more internalized and stigmatized behaviors like self-harm, suicide attempts, or suicidal ideation is less clear. This systematic review

synthesized evidence from sociometric school-based studies that examined associations between self-injurious thoughts and behaviors and peer-friendship networks in adolescence. There were a relatively limited number of sociometric studies (n = 15). Studies were heterogenous in their aims, methods, and analytical approaches, but measured (1) network structure and (2) exposure to friends' self-injurious thoughts and behaviors. This review highlights that in-school peer-friendship networks are associated with self-injurious thoughts and behaviors across the developmental period of adolescence (e.g., early to late adolescence). School-based friendship networks can be both beneficial and detrimental to adolescents' wellbeing (i.e., some network metrics were positively associated with self-injurious thoughts and behaviors, and some were negatively associated). Overall, this review found that not only were friends' self-injurious behaviors associated with adolescents' own similar behaviors, but the structure of *how* youth are connected to their school friends has implications for these behaviors, too, as discussed below.

Peer-friendship Networks and Self-injurious Thoughts and Behaviors

A wealth of studies measured network metrics that fit under the category of 'exposure to friends' self-injurious thoughts and behaviors.' There was evidence that having friends who report self-harm was positively associated with adolescents' subsequent self-harm (and there may be bi-directionality in that association), consistent with previous research that found peers can be influential for adolescent behaviors (Prinstein et al. 2001). However, only one study used a network model (SAOM) that is best practice in the field of social network analysis to disentangle socialization and selection, and this study only found evidence of *indirect* socialization of self-harm via friends' depressive symptoms (Giletta et al. 2013). Direct peer socialization and selection effects might be more likely depending on the nature of the connection. For example, although one study found that direct friends' self-harm was associated with adolescents' subsequent self-harm (Copeland et al. 2019), two other studies found that *reciprocal friends'* self-harm was longitudinally associated with adolescents' self-harm (You et al. 2013, 2016). Self-harm among close friends might be more discussed and visible, which may be key for these social processes to occur (Hall & Melia, 2022).

However, there were mixed findings for consequences of having friends with suicidal ideation and attempts. Of the five studies that measured this, three found positive associations with adolescents' own self-injurious thoughts and behaviors (Baller and Richardson 2009; Wyman et al. 2019; Zimmerman et al. 2016), whereas two did not (Ali et al. 2011; Mueller and Abrutyn 2015). Contradictory findings indicate the importance of intentional choices in operationalization of exposures and outcomes, covariates, and modelling, as different specifications may indicate different patterns of attempts/ideation. For example, one study used contemporaneous, and lagged peer indicators in their statistical models and 'percentage of friends' with self-injurious thoughts and behaviors' for their metric, which may have different effects compared with other types of models and operationalizations (Ali et al. 2011). However, other than the obvious heterogeneity between studies in terms of analyses, the discrepancy may also be because ideation is highly internalized and may be more hidden compared with self-harm and suicide attempts. This highlights the importance of recognizing that self-injurious thoughts and behaviors, although linked, may be associated with peer networks in different ways.

Of the structural network metrics, there was evidence that sociality and being part of overall dense friendship networks was associated with lower self-injurious thoughts and behaviors. This pattern suggests, for example, that youth who see themselves as belonging to the school peer network or are generally friendly and involved with peers (sociality) may also experience less risk for self-injurious thoughts and behaviors writ large. More dense, cohesive settings with interconnections among peers also relate to lower self-injurious thoughts and behaviors, suggesting that perhaps such groups can better buffer against mental distress or provide social support in ways that interrupt pathways to these behaviors.

Being isolated and being part of intransitive friendship groups was associated with higher self-injurious thoughts and behaviors. This pattern highlights risks of social isolation at this life stage when connections with peers become salient and important to healthy development. Youth who are relatively structurally disconnected from peers, independent of any perceptions of loneliness or isolation, may face substantial risks for self-injurious thoughts and behaviors. Friendships that are imbalanced, where friends are not friends with each other, may create stressful situations of balancing social demands or spanning identity groups that similarly intensify mental distress, relating to greater self-injurious ideation or behaviors.

There was limited evidence or mixed findings for all other structural metrics, likely due to the limited number of studies and heterogeneity of specific network metrics utilized across studies. Overall, these findings highlight that not only do direct friends' behaviors matter for an adolescent's own behaviors (discussed above), but the structure of *how* youth are connected to friends also matters, including isolation from peers, whether friends are friends with each other (intransitivity), whether teens see themselves as part

of the peer context (sociality), and even the overall structure of an entire school (density). This review expands the consideration of how peers matter for self-injurious thoughts and behaviors beyond perceptions or peer norms to show that how youth are embedded in their peer-networks on a micro (individual positions), meso (proximal-peer), and macro level (network-wide) indeed matters for self-injurious thoughts and behaviors, advancing our view of the peers and self-injury research.

Gender

Friendship networks are socially produced, and network metrics may only exert effects depending on age, context, and gender. Of the eleven studies that set out to test gender differences, six of those studies found that the network effects depended on gender, and this may be because peer relationships have different emotional and behavioral costs and benefits for boys and girls (Rose and Rudolph 2006). For example, two longitudinal studies found that isolation was positively associated with ideation/attempts among girls, but there was no strong evidence this was the case for boys (Bearman and Moody 2004; Haynie et al. 2006). One explanation is that girls typically engage in "*more prosocial interactions characterized by social conversation and self-disclosure*" and lacking this (i.e., isolation) might have higher detrimental effects compared with boys who typically receive "*fewer emotional provisions in friendships*" (Rose and Rudolph 2006). Similarly, one study found that higher scores on the intransitivity index were positively associated with ideation for girls (but no evidence for boys) (Bearman and Moody 2004), suggesting social networks may only be protective for girls when their friends are friends with one another, which is consistent with additional research (Falci and McNeely 2009). However, the limited number of studies and reliance on self-report measures of self-injurious thoughts and behaviors mean that it is possible gender differences could be attributed to the reporting of the behavior (i.e., boys might be less likely to self-report self-injurious thoughts and behavior or view the behaviors the same way as girls), although research on this is lacking (Fox et al. 2018; Stillion et al., 1989).

Age and Adolescent Development

Adolescence is an age-period where many social, emotional, and developmental changes occur, and youth spend a large proportion of their time in school across stages of development (Eccles and Roeser 2011). In this review, most studies had samples of youth with an age range that spanned across the period of adolescence (i.e., ages 11–19) with mean ages for those samples between 14 and 16 years of age (mid-adolescence). However, some studies had samples that spanned either early, mid-to-late, or late adolescence only. Thus, being part of an in-school peer-friendship network might have different costs and benefits at different stages of adolescence, including how peers might relate to the development and maintenance of self-injurious thoughts and behaviors.

One study focused on a sample of younger adolescents from one middle-school in the USA (i.e., early adolescence) and this study also explicitly examined differences across age (Prinstein et a. 2010). They found that grade was a moderator of the association between friends' self-harm and adolescents' subsequent self-harm among girls (i.e., the effect was stronger among girls in lower grades). Given that previous studies have found the average age of onset for self-harm is around 12–13 years of age, with an increase and peak during mid-adolescence (Gillies et al. 2018; Plener et al. 2015), this age might be a key time to intervene for self-harm, and given the effects of friends' behaviors, creating interventions informed by peer networks and shared social motivations for self-injury may prove particularly beneficial. This study also suggests that network metrics might exert different effects depending on age, indicating that different developmental stages within adolescence may have heightened sensitivity to peer network associations with self-injurious thoughts and behaviors, such as stronger susceptibility to effects from peer self-injury in early adolescence that may wane, or shift focus as adolescents develop.

However, there was also evidence to suggest peers are influential for these behaviors in both mid-to-late adolescence, and later adolescence, too. For example, two studies focused on the period of later adolescence (age ranges of 16–19 at baseline) (Copeland et al. 2019; Giletta et al. 2015). Both studies found that peers' self-injurious thoughts and behaviors were associated with an adolescents' own self-injurious thoughts and behaviors, and one of those studies also found that network structure (i.e., bridging others in a network and sociality) was associated with self-harm among adolescents. Therefore, it seems that across the developmental period of adolescence, peers, and the structure of how youth are connected to their peers are salient and important for these behaviors. However, due to the limited number of studies in this review and a low variability of age across samples, it was difficult to draw definitive conclusions about more specific characteristics of peer-networks and different developmental periods (e.g., early, mid, late adolescence).

Methodological Limitations of Existing Studies

There were several limitations regarding the literature in this review. Eight studies utilized data from Add Health

(Harris et al. 2019), two studies used data from the same eight co-educational high schools, and five were from other independent studies (in the USA and China). Thus, data in this review came from a pool of seven independent studies in just two countries, which means the findings were highly context specific and this reduces the strength and generalizability of the evidence. Studies did not assess outcomes and metrics equally (e.g., only six studies measured self-harm as an outcome, and only one study measured individual positions within a network and self-harm), limiting any strong conclusions that can be made for most network metrics and specific self-injurious thoughts and behaviors.

Challengingly, there was a large variation in terms of analytical approaches, measurement of network metrics, and covariates used which made comparisons across studies difficult. For example, one study assessed whether network metrics mediated the effect between being a residential mover and suicide attempts (Haynie et al. 2006), some studies adjusted for peer support and school connectedness (potential mediators) (Xiao and Lindsey 2021), and one cross-sectional study adjusted for the potential confounding effects of depression, violence victimization, and bullying (and found that some of the peer effects they present in their main results decreased in magnitude or were no longer independently associated) (Wyman et al. 2019). Many of the covariates adjusted for in these studies might lie on the causal pathway between network metrics and self-injurious thoughts and behaviors and measuring many network metrics at once might indicate some matter more than others. Moreover, prior research suggests potential mediation and moderation for peer influence processes that have largely not yet been assessed (Prinstein 2007) (e.g., social anxiety, friends perceived popularity, friendship quality), and little research has addressed what might influence structural network effects.

A further limitation of school-based studies is that adolescents at risk for self-injurious thoughts and behaviors might be more likely to miss school. Some studies assessed the extent of attrition bias e.g., one study found that "*Attrition was mainly due to students transferring to other schools or being absent from school on the day of assessment*", but comparisons revealed no significant differences between those missing and non-missing (You et al. 2013). However, studies were variable and inconsistent in the way they reported attrition - only six studies were explicitly clear about response rates within their studies, with rates ranging from 66 to 99%.

Within the field of social network analysis, there is no established recommendation for collecting sociometric data, measuring metrics, or for reporting. Thus, studies in this review measured friendship nominations and metrics in various ways. For example, one study asked adolescents to nominate an unlimited number of friends and they excluded a few students who nominated an implausibly high number of friends (Giletta et al. 2013). Other studies asked students to nominate their '*five closest male and female friends'*. Careful consideration is needed for how sociometric questions are asked and the caveats they may bring. Interestingly, one study looked at adolescents' close relationships with adults within the school (Wyman et al. 2019) as well as friends, and it is worth noting that although there are many strengths associated with using bounded network data, important relationships in adolescence may not be bounded in a school network.

Strengths and Limitations of the Review

A key strength of this review is its focus on sociometric 'whole network' studies. We excluded studies that did not meet our exact criteria: for example, one study measured exposure to self-harm among adolescents' close dyadic friendships, but this study was excluded from our review as the measure was not sociometric and was conducted in a lab-based setting (Schwartz-Mette and Lawrence 2019). We excluded two studies that measured peer preference by using 'liking' as a tie definition (Heilbron and Prinstein 2010; Giletta et al. 2012) and we excluded an interventional study that utilized sociometric data but only to predict exposure to an intervention and not suicidality (Pickering et al. 2018). Lastly, we excluded a study that used a friendship nomination procedure where adolescents were asked to write the 'initials of a friend they were thinking about' but these nominations could not be linked together into a larger sociometric web (Prinstein et al. 2001).

However, there were some limitations. Network metrics can be operationalized in many ways and there is no standard approach among the field for organizing them. Synthesizing studies about self-injurious thoughts and behaviors from this complex field means there may be some discord with the way metrics are taxonomized here. Some metrics were simple to group, e.g., one study (Baller and Richardson. 2009) noted that they measure the intransitivity index in the same way as another study (Bearman and Moody. 2004). However, other metrics were more difficult to group, such as one study that measured 'reciprocal friends self-harm' which is inherently both exposure and structure (Giletta et al. 2015). Many studies did this in some fashion, creating a challenge in trying to distinguish different levels of networks: some only measure reciprocal friends, some direct friends (transitivity/peer-network density), some combine information from direct and indirect ties (bonacich centrality, betweenness centrality), and some were network-wide.

Common to other systematic reviews, we only included peer-reviewed studies. The field of self-injurious thoughts

and behaviors and networks is relatively young which means that findings from unpublished theses and grey literature may be published and relevant in the next few years. This review used a clearly defined search strategy across five databases (with no date limit) and forward and backward citation searching was conducted. However, studies were not uniform in the way they described network processes e.g., (diffusion, influence, socialization) and metrics can be described in different ways e.g., (popularity/in-degree, sociality/out-degree, betweenness centrality/bridging). It is possible that some eligible studies may have been missed.

Implications and Future Research

Self-injurious thoughts and behaviors are a concerning health challenge among adolescents, and this review highlights that peer-friendship networks are an important consideration in that challenge. However, due to the limited number of studies and comparable samples, it is clear there is a need for the collection of newer sociometric datasets from school-age adolescents on their friendship networks and self-injurious thoughts and behaviors.

Rising self-harm among young people (Morgan et al. 2017) suggests increased opportunity for exposure, and given the effects of friends' behaviors in this review, further research into peer influence and selection of self-injurious thoughts and behaviors is important. Future studies should consider using specific network models (e.g., SAOMs) that are more equipped to manage the complexities of interdependent social network data and that can help to disentangle socialization and selection processes. Understanding if socialization and/or selection is at play is particularly important as it could directly inform the development of prevention programs for these behaviors within schools. Therefore, future research should use longitudinal network data to better understand dynamic network processes, direction of effects, as well as the mechanisms of how network metrics might exert their effects.

Although friends' behaviors are important, this review also highlights that the structure of *how* youth are connected is also important to consider, too (e.g., sociality and dense friendship networks were negatively associated with self-injurious thoughts and behaviors, whereas intransitivity and isolation were positively associated). Further research should focus on structural network metrics to further develop our understanding of micro, meso, and macro level features of a friendship network and associations with self-injurious thoughts and behaviors.

Beyond the implications for network researchers, these findings also have implications for adolescents, those that work with adolescents, and developing interventions for reducing self-injurious thoughts and behaviors in schools. Clinical guidelines in the UK from the National Institute for Health and Care Excellence have already recognized the importance of schools and in-school peers for self-harm (National Institute for Health and Care Excellence 2022). However, this review further highlights that those working with youth should consider risks for youth that are isolated or part of imbalanced friendships and encourage teens to see themselves as part of the school social environment and connect with others (sociality).

Adolescence is a developmental period where many social and developmental changes occur, but adolescents' sensitivity to peers may wane or shift focus during development. In this review, there was evidence that peers shape self-injurious thoughts and behaviors across the developmental period of adolescence, though heterogeneity in measures and samples across studies limited comparison about specific network metrics across different stages of adolescence. Thus, future studies should consider different developmental periods within adolescence (e.g., early, mid, late adolescence) and if specific network metrics might have different developmentally salient effects for self-injurious thoughts and behaviors during these times. Research should also consider that adolescence does not have a definitive 'cut-off' point and adolescent development can extend well into the 20s (Sawyer et al. 2018).

Studies in this review came from only two countries, and there was little evidence about how other markers of diversity (such as race/ethnicity or sexual minority youth) matter for peer-networks and self-injurious thoughts and behaviors. There is some evidence (from non-network studies outside of this review) that suggest self-injurious thoughts and behaviors differ among different social groups such as marginalized and minority ethnic groups (Bhui et al. 2007) and are more prevalent among sexual minority youth compared with their heterosexual counterparts (Taliaferro and Muehlenkamp 2017). Studies in more diverse populations are needed to better understand how key dimensions of identity and intersectionality are related to both self-injurious thoughts and behaviors and associations with peer-friendship networks.

The limited number of studies in this review meant that it was not viable to synthesize evidence by the *type* of self-injurious thought and behavior outcome. Although self-injurious thoughts and behaviors are linked behaviors, suicidal ideation is arguably a less visible internalized process compared with self-harm and suicide attempts (although these can also be hidden behaviors). Therefore, further research is needed that can better understand how peer-networks might relate to self-harm, ideation, and attempts differently.

Importantly, as the field of social network analysis and self-injurious thoughts and behaviors develops, there is a need for standardization in sociometric data collection,

measurement of network metrics and analyses, greater consistency regarding the covariates that are included in analyses, and standard reporting of attrition and response rates. Reporting guidelines developed by the experts who developed these methods could help to make future studies in this field more systematic and easier to synthesize, like that for other complex methods/analyses, such as trajectory modelling (van de Schoot et al. 2017).

Extending best practice for systematic reviews to sociometric studies requires an adequate risk of bias tool that can identify biases that come with the interdependencies of network data and the methods used to collect this kind of data. This systematic review evaluated two risk of bias tools (Sabot et al. 2017, Knox et al., 2019) used in previous reviews of sociometric studies. Both tools were adequate, but the Sabot et al. (2017) tool addressed more questions that were specifically related to potential biases with network data and thus is the recommendation from this review.

Conclusion

Adolescent development research highlights how peers, particularly in-school peers, are socially salient and influential for health behavior. Self-injurious thoughts and behaviors are a prominent health challenge among adolescents, and studies have shown that, despite being largely internalized and stigmatized processes, they may also be shaped by peers. However, it was unclear exactly how school-based peer-friendship networks may be associated with these behaviors. This systematic review synthesized the evidence from sociometric studies of school-based friendship networks and associations with self-injurious thoughts and behaviors. This review highlights that not only do peers' self-injurious thoughts and behaviors matter for adolescents' own similar behaviors, but the structure of *how* adolescents are embedded in their school-peer network is also important to consider, whether it is how the whole school functions (density), individual positions (isolation), or how cohesive an adolescent's direct and indirect friendships are (intransitivity). Although the heterogeneity of studies in this review mean that it is difficult to draw clear conclusions about *specific* networks metrics and self-injurious thoughts and behaviors, what *is* clear is that the structure of peer-friendship networks is critical to consider for these behaviors, because a wide variety of measures that capture many different aspects of peer-friendship networks strongly relate to self-injurious thoughts and behaviors across multiple studies. Furthermore, peers matter for these behaviors across the developmental stages in adolescence (i.e., from early to late adolescence). Further longitudinal research is needed that uses newer sociometric datasets to better understand dynamic network processes as well as how and why these network metrics might exert their effects. Future research should also consider how different developmental stages of adolescence and other indicators of diversity might have different consequences for self-injurious thoughts and behaviors and peer networks. Creating interventions informed by peer networks and shared social motivations for self-injurious thoughts and behaviors may prove particularly beneficial.

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Declarations

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References

*Ali, M. M., Dwyer, D. S., & Rizzo, J. A. (2011). The Social Contagion Effect of Suicidal Behavior in Adolescents: Does it Really Exist? *Journal of Mental Health Policy and Economics*, *14*(1), 3–12.

*Baller, R. D., & Richardson, K. K. (2009). The "Dark Side" of the Strength of Weak Ties: The Diffusion of Suicidal Thoughts. *Journal of Health and Social Behavior*, *50*(3), 261–276.

*Bearman, P. S., & Moody, J. (2004). Suicide and Friendships Among American Adolescents. *American Journal of Public Health*, *94*(1), 89–95.

Bentley, K. H., Nock, M. K., & Barlow, D. H. (2014). The Four-Function Model of Nonsuicidal Self-Injury: Key Directions for Future Research. *Clinical Psychological Science*, *2*(5), 638–656.

Bhui, K., McKenzie, K., & Rasul, F. (2007). Rates, risk factors & methods of self harm among minority ethnic groups in the UK: a systematic review. *Bmc Public Health*, *7*(1), 1–14.

Blakemore, S. J. (2018). Avoiding Social Risk in Adolescence. *Current directions in psychological science*, *27*(2), 116–122.

Brown, B. B., & Larson, J. (2009). Peer Relationships in Adolescence. In R. M. Lerner, & L. Steinberg (Eds.), *Handbook of Adolescent Psychology*. Hoboken, NJ, USA: John Wiley & Sons, Inc.

*Copeland, M., Siennick, S. E., Feinberg, M. E., Moody, J., & Ragan, D. T. (2019). Social Ties Cut Both Ways: Self-Harm and Adolescent Peer Networks. *Journal of Youth and Adolescence*, *48*(8), 1506–1518.

*De Luca, S. M., Wyman, P., & Warren, K. (2012). Latina Adolescent Suicide Ideations and Attempts: Associations with Connectedness to Parents, Peers, and Teachers: Latina Adolescent Suicide. *Suicide and Life-Threatening Behavior*, *42*(6), 672–683.

Eccles, J. S., & Roeser, R. W. (2011). Schools as Developmental Contexts During Adolescence. *Journal of Research on Adolescence*, *21*(1), 225–241.

Falci, C. D., & McNeely, C. (2009). Too Many Friends: Social Integration, Network Cohesion and Adolescent Depressive Symptoms. *Social Forces*, *4*(87), 2031–2061.

Fletcher, J. M. (2017). Gender-specific Pathways of Peer Influence on Adolescent Suicidal Behaviors. *Socius: Sociological Research for a Dynamic World*, *3*.

Fox, K. R., Millner, A. J., Mukerji, C. E., & Nock, M. K. (2018). Examining the role of sex in self-injurious thoughts and behaviors. *Clinical Psychology Review*, *66*, 3–11.

*Giletta, M., Burk, W. J., Scholte, R. H. J., Engels, R. C., M., E., & Prinstein, M. J. (2013). Direct and Indirect Peer Socialization of Adolescent Nonsuicidal Self-Injury. *Journal of Research on Adolescence*, *23*(3), 450–463.

*Giletta, M., Prinstein, M. J., Abela, J. R. Z., Gibb, B. E., Barrocas, A. L., & Hankin, B. L. (2015). Trajectories of suicide ideation and nonsuicidal self-injury among adolescents in mainland China: Peer predictors, joint development, and risk for suicide attempts. *Journal of Consulting and Clinical Psychology*, *83*(2).

Giletta, M., Scholte, R. H. J., Engels, R. C. M. E., Ciairano, S., & Prinstein, M. J. (2012). Adolescent non-suicidal self-injury: A cross-national study of community samples from Italy, the Netherlands and the United States. *Psychiatry Research*, *197*(1–2), 66–72.

Gillies, D., Christou, M. A., Dixon, A. C., Featherston, O. J., Rapti, I., Garcia-Anguita, A., et al. (2018). Prevalence and Characteristics of Self-Harm in Adolescents: Meta-Analyses of Community-Based Studies 1990–2015. *Journal of the American Academy of Child & Adolescent Psychiatry*, *57*(10), 733–741.

Hall, S., & Melia, Y. (2022). What is Known About the Role of Friendship in Adolescent Self-Harm? A Review and Thematic Synthesis. *Child & Youth Care Forum*,1–26.

Harris, K. M., Halpern, C. T., Whitsel, E. A., Hussey, J. M., Killeya-Jones, L. A., Tabor, J., & Dean, S. C. (2019). Cohort Profile: The National Longitudinal Study of Adolescent to Adult Health (Add Health). *International Journal of Epidemiology*, *48*(5), 1415–1415k.

*Haynie, D. L., South, S. J., & Bose, S. (2006). Residential Mobility and Attempted Suicide Among Adolescents: An Individual-Level Analysis. *The Sociological Quarterly*, *47*(4), 693–721.

Heilbron & Prinstein. (2010). Adolescent Peer Victimization, Peer Status, Suicidal Ideation, and Nonsuicidal Self-Injury: Examining Concurrent and Longitudinal Associations. *Merrill-Palmer Quarterly*, *56*(3), 388–419.

Jarvi, S., Jackson, B., Swenson, L., & Crawford, H. (2013). The Impact of Social Contagion on Non-Suicidal Self-Injury: A Review of the Literature. *Archives of Suicide Research*, *17*(1), 1–19.

Knox, J., Schneider, J., Greene, E., Nicholson, J., Hasin, D., & Sandfort, T. (2019). Using social network analysis to examine alcohol use among adults: A systematic review. *PLOS ONE*, 14(8), e0221360.

Leung, R. K., Toumbourou, J. W., & Hemphill, S. A. (2014). The effect of peer influence and selection processes on adolescent alcohol use: a systematic review of longitudinal studies. *Health Psychology Review*, *8*(4), 426–457.

Lo, C. K. L., Mertz, D., & Loeb, M. (2014). Newcastle-Ottawa Scale: comparing reviewers' to authors' assessments. *BMC Medical Research Methodology*, *14*(1), 45.

Mars, B., Heron, J., Klonsky, E. D., Moran, P., O'Connor, R. C., Tilling, K., et al. (2019). What distinguishes adolescents with suicidal thoughts from those who have attempted suicide? A population-based birth cohort study. *Journal of Child Psychology and Psychiatry*, *60*(1), 91–99.

Montgomery, S. C., Donnelly, M., Bhatnagar, P., Carlin, A., Kee, F., & Hunter, R. F. (2020). Peer social network processes and adolescent health behaviors: A systematic review. *Preventive Medicine*, *130*, 105900.

*Mueller, A. S., & Abrutyn, S. (2015). Suicidal Disclosures among Friends: Using Social Network Data to Understand Suicide Contagion. *Journal of Health and Social Behavior*, *56*(1), 131–148.

National Institute for Health and Care Excellence (2022). Self-harm: assessment, management and preventing recurrence, NICE guideline [NG225], 81. https://www.nice.org.uk/guidance/ng225.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Systematic Reviews*, *10*(1), 89.

Pickering, T. A., Wyman, P. A., Schmeelk-Cone, K., Hartley, C., Valente, T. W., Pisani, A. R., et al. (2018). Diffusion of a Peer-Led Suicide Preventive Intervention Through School-Based Student Peer and Adult Networks. *Frontiers in Psychiatry*, *9*, 598.

Plener, P. L., Schumacher, T. S., Munz, L. M., & Groschwitz, R. C. (2015). The longitudinal course of non-suicidal self-injury and deliberate self-harm: a systematic review of the literature. *Borderline Personality Disorder and Emotion Dysregulation*, *2*(1), 2.

Potard, C., Courtois, R., & Rusch, E. (2008). The influence of peers on risky sexual behaviour during adolescence. *The European Journal of Contraception & Reproductive Health Care*, *13*(3), 264–270.

Prinstein, M. J. (2007). Moderators of Peer Contagion: A Longitudinal Examination of Depression Socialization Between Adolescents and Their Best Friends. *Journal of Clinical Child & Adolescent Psychology*, *36*(2), 159–170.

Prinstein, M. J., Boergers, J., & Spirito, A. (2001). Adolescents' and Their Friends' Health-Risk Behavior: Factors That Alter or Add to Peer Influence. *Journal of Pediatric Psychology*, *26*(5), 287–298.

*Prinstein, M. J., Heilbron, N., Guerry, J. D., Franklin, J. C., Rancourt, D., Simon, V., & Spirito, A. (2010). Peer Influence and

Nonsuicidal Self Injury: Longitudinal Results in Community and Clinically-Referred Adolescent Samples. *Journal of Abnormal Child Psychology*, *38*(5), 669–682.

Prinstein, M. J., & Wang, S. S. (2005). False Consensus and Adolescent Peer Contagion: Examining Discrepancies between Perceptions and Actual Reported Levels of Friends' Deviant and Health Risk Behaviors. *Journal of Abnormal Child Psychology*, *33*(3), 293–306.

Quigley, J., Rasmussen, S., & McAlaney, J. (2017a). The Associations Between Children's and Adolescents' Suicidal and Self-Harming Behaviors, and Related Behaviors Within Their Social Networks: A Systematic Review. *Archives of Suicide Research*, *21*(2), 185–236.

Quigley, J., Rasmussen, S., & McAlaney, J. (2017b). The Social Norms of Suicidal and Self-Harming Behaviours in Scottish Adolescents. *International Journal of Environmental Research and Public Health*, *14*(3), 307.

Rose, A. J., & Rudolph, K. D. (2006). A review of sex differences in peer relationship processes: Potential trade-offs for the emotional and behavioral development of girls and boys. *Psychological Bulletin*, *132*(1), 98–131.

Sabot, K., Wickremasinghe, D., Blanchet, K., Avan, B., & Schellenberg, J. (2017). Use of social network analysis methods to study professional advice and performance among healthcare providers: a systematic review. *Systematic Reviews*, *6*(1), 208.

Sawyer, S. M., Azzopardi, P. S., Wickremarathne, D., & Patton, G. C. (2018). The age of adolescence. *The Lancet Child & Adolescent Health*, *2*(3), 223–228.

Schwartz-Mette, R. A., & Lawrence, H. R. (2019). Peer Socialization of Non-Suicidal Self-Injury in Adolescents' Close Friendships. *Journal of Abnormal Child Psychology*, *47*(11), 1851–1862.

Snijders, T. A. B., van de Bunt, G. G., & Steglich, C. E. G. (2010). Introduction to stochastic actor-based models for network dynamics. *Social Networks*, *32*(1), 44–60.

Stevens, E. A., & Prinstein, M. J. (2005). Peer Contagion of Depressogenic Attributional Styles Among Adolescents: A Longitudinal Study. *Journal of Abnormal Child Psychology*, *33*(1), 25–37.

Stillion, J., White, H., Edwards, P. J., & McDowell, E. (1989). e. Ageism and sexism in suicide attitudes. *Death Studies*, *13*(3), 247–261.

Syed, S., Kingsbury, M., Bennett, K., Manion, I., & Colman, I. (2020). Adolescents' knowledge of a peer's non-suicidal self-injury and own non-suicidal self-injury and suicidality. *Acta Psychiatrica Scandinavica*, *142*(5), 366–373.

Taliaferro, L. A., & Muehlenkamp, J. J. (2017). Nonsuicidal Self-Injury and Suicidality Among Sexual Minority Youth: Risk Factors and Protective Connectedness Factors. *Academic Pediatrics*, *17*(7), 715–722.

van de Schoot, R., Sijbrandij, M., Winter, S. D., Depaoli, S., & Vermunt, J. K. (2017). The GRoLTS-Checklist: Guidelines for Reporting on Latent Trajectory Studies. *Structural Equation Modeling: A Multidisciplinary Journal*, *24*(3), 451–467.

Van Orden, K. A., Witte, T. K., Cukrowicz, K. C., Braithwaite, S. R., Selby, E. A., & Joiner, T. E. (2010). The interpersonal theory of suicide. *Psychological Review*, *117*(2), 575–600.

Wasserman, S., & Faust, K. (1994). *Social Network Analysis: Methods and Applications*. Cambridge: Cambridge University Press.

World Health Organization (2021). Suicide worldwide in 2019: global health estimates. https://www.who.int/publications/i/item/9789240026643. Accessed 15 September 2022.

*Wyman, P. A., Pickering, T. A., Pisani, A. R., Rulison, K., Schmeelk-Cone, K., Hartley, C., et al. (2019). Peer-adult network structure and suicide attempts in 38 high schools: implications for network-informed suicide prevention. *Journal of Child Psychology and Psychiatry*, *60*(10), 1065–1075.

*Xiao, Y., & Lindsey, M. A. (2021). Adolescent social networks matter for suicidal trajectories: disparities across race/ethnicity, sex, sexual identity, and socioeconomic status. *Psychological Medicine*,1–12.

*You, J., Lin, M. P., Fu, K., & Leung, F. (2013). The Best Friend and Friendship Group Influence on Adolescent Nonsuicidal Self-injury. *Journal of Abnormal Child Psychology*, *41*(6), 993–1004.

*You, J., Zheng, C., Lin, M., & Leung, F. (2016). Peer group impulsivity moderated the individual-level relationship between depressive symptoms and adolescent nonsuicidal self-injury. *Journal of Adolescence*, *47*(1), 90–99.

Youniss, J., & Haynie, D. L. (1992). Friendship in Adolescence. *Journal of Developmental & Behavioral Pediatrics*, *13*(1), 59–66.

*Zimmerman, G. M., Rees, C., Posick, C., & Zimmerman, L. A. (2016). The power of (Mis)perception: Rethinking suicide contagion in youth friendship networks. *Social Science & Medicine*, *157*, 31–38.