Navigating the social maze: An integrative review on the social network properties of deviant peer influence in adolescent networks

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Funding details: This work was supported by the Research Foundation – Flanders (FWO) under Grant 1111524N.

Disclosure statement: The authors report there are no competing interests to declare.

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Abstract

Social network analysis (SNA) holds great potential for examining the influence of peers and group dynamics on the development of criminal behavior among adolescents as it offers a robust framework for studying complex social interactions. However, there needs to be more knowledge regarding key research findings on deviant adolescent influence using a social network approach. In this integrative literature review, we examine what type of information is used to construct adolescents' social networks, how network compositions affect deviant influence, and how deviant influence is transmitted. For this review, we selected 39 articles by searching Scopus and Web of Science. The results demonstrate that SNA offers valuable insights into the dynamics of deviant peer influence among adolescents. However, there are also conflicting findings that need further exploration. Future research could focus on these discrepancies and continue to leverage the power of SNA in studying the development of criminal behavior in adolescents. This review highlights the importance of SNA in better understanding the mechanisms behind peer influence and provides a roadmap for future research in this field.

Keywords: social network analysis, youth criminology, deviance, peer influence

Introduction

The role of peer influence and group processes in developing criminal behavior is a core idea in the criminology field (Akers 1998; Pratt et al. 2010; Warr 2002). Various social structures, such as gangs and demographic groups, can facilitate social learning processes that lead to the adoption and development of delinquent attitudes and behaviors (Nicholson and Higgins 2017). Social network analysis (SNA) is a promising and innovative technique for studying these influence dynamics (Papachristos 2011). Unlike traditional individual-focused approaches, SNA examines the relationships and interactions to understand human behavior (Marin and Wellman 2014; McGloin and Kirk 2010; Wasserman and Faust 1994).

Adolescence is a crucial period for peer influence in delinquent and risk-taking behavior (e.g., Chein et al. 2011; Paus et al. 2008; Steinberg 2008), with research indicating a high co-offending rate among adolescents for various offences (Andresen and Felson 2012). These co-offending relationships are often unstable, as adolescents tend to switch co-offenders frequently (McGloin and Kirk 2010). Thus, the complex and shifting compositions of peer networks provide opportunities for SNA to advance our understanding of the influence of peers on adolescent delinquency.

While some overview articles highlight the benefits of using SNA to study crime dynamics and peer influence (Bouchard and Malm 2016; Carrington 2014; Hoeben et al. 2016; McGloin and Kirk 2010), a comprehensive overview of the leading research findings on deviant adolescent influence using social network techniques, is lacking. This review article aims to fill this gap and identify (1) what information is used to construct social deviance networks of adolescents, (2) how social network compositions of adolescent networks affect deviant influence, and consequently, (3) how deviant influence is transmitted in social networks of adolescents.

In this way, we aim to make a significant contribution to the field of network criminology by deepening our understanding of the intricate relationship between peer influence within adolescent social networks and the development of deviant behavior in adolescents. We expect that the findings derived from this study will inform current policies and interventions by highlighting crucial network positions in the spread of deviant behavior. Moreover, these insights will chart a course for future research in network criminology. By identifying gaps in the existing literature and emphasizing areas requiring further exploration, this study can serve as a roadmap for future investigations.

To answer these questions, we first provide a brief discussion of SNA, and then, describe the literature search strategy. Next, we discuss the data, the adopted methods, and the main findings of the extracted studies. Finally, our review emphasizes the potential of SNA in advancing our understanding of peer influence on adolescent delinquency and provides recommendations for future research and policymakers.

Social network analysis: core concepts and methods

A social network comprises individuals referred to as 'nodes' or 'vertices', which can be connected by 'edges' or 'links' that represent different types of social relationships, such as friendship, co-membership, or co-offending (McGloin and Kirk 2010; Newman 2010; Wasserman and Faust 1994). In addition to having attributes like age and gender, nodes can also have weighted edges that reflect their relationship's strength. Furthermore, the directionality of edges adds further complexity to the relational patterns (Marin and Wellman 2014; Newman 2010). Various network measures can be applied to analyze these network properties, yielding insights into the social network's overall structure and the social positions of individual nodes.

Network structure

When analyzing network structure, fundamental measures such as centrality and connectivity provide insights into the network's composition and node positions within it. A key measure is the node degree, which represents the number of attached edges to the node, followed by the average degree, representing the average number of links per node in the network (Newman 2010). By normalizing the degree by the number of network nodes, one can define the degree centrality of the node for a given network. An adolescent with a high degree centrality has many links to others in the networks and, thus, a relatively higher influence potential in that particular network. The degree centrality could be further elaborated by using a standardization score to include the degree variance of the respective network. In directed networks, degree centrality can be further divided into in-degree (incoming links or influence) and out-degree (outgoing links or influence) (Tabassum et al. 2018). In adolescent relationships, in-degree centrality (k_{in}^{i}) is often used as a measure of 'popularity', reflecting the number of friendship nominations an adolescent receives (e.g., Copeland et al. 2019; Dijkstra et al. 2012).

$$k_{in}^{i} = \sum_{j} e_{ij}\,^{1}$$

However, the Bonacich centrality provides a more nuanced popularity parameter by considering the popularity of an adolescent's friends in addition to their own (Schreck, Fisher, and Miller 2004; Stogner et al. 2014). This measure considers whether a popular adolescent is also surrounded by popular friends, which may indicate high social status

[1] e_{ij} represents the presence or absence of an edge between nodes i and j.

(Copeland et al. 2019). Therefore, an adolescent with high Bonacich centrality (C_i) is a popular individual who moves around in popular circles within the adolescent network.

$$C_i(\alpha, \beta) = \sum_j (\alpha + \beta c_j) R_{ij}$$ [2]

While the degree of a network provides information about the node's centrality in terms of its local connectivity, it offers limited insights into the structural positions or influence potential of those nodes within the network, i.e. beyond the nearest neighbors. Other centrality measures, such as betweenness centrality, focus on identifying the importance of nodes based on their ability to act as intermediaries in the dissemination of information (Golbeck 2015; Wasserman and Faust 1994). A high betweenness value (b_i) indicates that a node (i) lies on many paths between other nodes (σ_{jk}), making it an influential player in the network (Tabassum et al. 2018).

$$b_i = \sum_{i \neq j \neq k} \frac{\sigma_{jk}(i)}{\sigma_{jk}}$$

Through this measure, researchers can estimate the brokerage potential or bridging capacity of nodes. A broker or bridge is a node that connects separate groups of nodes, providing a crucial link between them (Tabassum et al. 2018). In the context of adolescent relationships, this could be an adolescent who is part of several distinct groups and can exert influence over those groups, making them particularly relevant for studies of peer influence (Copeland et al. 2019; Rulison, Gest, and Osgood 2015).

Lastly, the structural distance between nodes can be quantified to determine how socially far nodes are from each other, and hence can be used to examine how quickly

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[2] As α controls the influence of direct links, and β refers to the influence of indirect links, ($\alpha + \beta c_j$) represents the weight assigned to each neighbor j. R_{ij} indicates whether a direct link exists between i and j in the network's adjacency matrix.

influence can spread in the social network (Tabassum et al. 2018). This measure also helps to identify the point at which influence diminishes. For instance, the diameter (*D*) of a network – or the length of the longest geodesic path between any pair of nodes (Newman, 2010) – provides insights into the farthest minimum path in the network and thus the minimum number of steps needed to reach any other node from a given source (Tabassum et al., 2018). A sparse adolescent network has lower density of social interactions (Kaiser 2008) which may reduce the reachability and influenceability of key nodes.

$$D = max_i \epsilon(\mathrm{i})$$ [3]

Node interactions

One way to measure the level of local cohesion between a node's neighbors is through the concept of transitivity or network clustering (Newman 2010; Tabassum et al. 2018). A high level of transitivity indicates that the neighbors of a node are also connected to each other, creating a clustering effect. In the context of adolescent peer influence, transitivity refers to the degree to which an adolescent is connected to friends of friends (Dijkstra et al. 2012; Gremmen et al. 2019).

Reciprocity is another measure to examine the behavior of nodes in a network, which reflects the extent to which the edges of a node are reciprocated. In the context of adolescent relationships, reciprocity indicates that the nominated friends of a respondent also consider that respondent as their friend.

[3] $\epsilon(\mathrm{i})$ represents the eccentricity, which indicates the maximal shortest path length of a node with any other node in the network.

Methodology

We employed the 'integrative review' method (Booth, Papaioannou, and Sutton 2016) to systematically synthesize and analyze the existing literature on the topic. This approach involves integrating knowledge from various research fields to gain insights into a phenomenon, and helps to identify key issues and research gaps in the target field of study (Cronin and George 2020; Russell 2005). Given that our study revolves around SNA, situated at the crossroads of various disciplines, this approach proves particularly relevant. Furthermore, the systematic character of the integrative review approach allows us to conduct an in-depth analysis of our specific research questions.

We established the following criteria to evaluate the eligibility of the articles:

(1) **Medium**: To maintain the scientific rigor of our review, we excluded unpublished articles, conference papers, and PhD dissertations.

(2) **Language**: We included studies in English, Dutch, and French, given the authors' language proficiency.

(3) **Topic:** We included studies that examined the effect of social influence and/or transmission on deviance.

(4) **Study design:** We limited our review to empirical and original research articles.

(5) **Perspective:** We included studies focusing on social networks and/or social network analysis.

(6) **Study population:** We focused on studies that examined adolescents' social networks. This study population was chosen because peer influence is particularly significant during adolescence, and adolescents exhibit a greater tendency to engage in co-offending compared to adults (Andresen & Felson 2012). We adopted the WHO definition of adolescents as individuals having ages between 10 and 19 (e.g., World Health Organization n.d.).

We conducted a literature search and extraction in May 2022, limited to studies published before this month. Our search was performed using Scopus, as this online database has high performance rates in terms of both precision and recall (Mourão et al. 2020). To supplement our search, we utilized the curated database Web of Science (WoS), which allows for the use of Boolean operators. The purpose of combining these databases was to obtain a larger pool of articles. Additionally, Scopus and WoS only index peer-reviewed scholarly articles (Halevi, Moed, and Bar-Ilan 2017), which enhances the likelihood of collecting recognized scientific articles.

We employed various keyword combinations. For Scopus, we used the following combinations: 1) social AND influence AND network AND (crim* OR delinq* OR offend*), 2) "social network" AND (crim* OR delinq* OR offend*) AND spread, 3) network AND contagion AND (crim* OR delinq* OR offend*), and 4) social AND contagion AND (crim* OR delinq* OR offend*). This resulted in 609, 147, 43, and 110 matches, respectively, for a total of 909 sources. For WoS, we used the following keyword combinations: 1) contagion AND network AND (crim* OR delinq* OR offend*), 2) social AND contagion AND (crim* OR delinq* OR offend*, and 3) spread AND network AND social AND (crim* OR delinq* OR offend*). This yielded 68, 213, and 203 matches, respectively, for a total of 484 sources. The initial total sample hence consisted of 1393 sources[4].

[4] The full Endnote database can be found here: https://github.com/JokeGeeraert/PhD-project_JokeGeeraert/blob/88f71fbe79a7bcbc395a70563299a095f99df349/EndNote%20library.bib

After removing duplicates (n = 267), we applied the predefined selection criteria to narrow down the selection of articles. We assessed the title first, followed by the abstract and, if necessary, the full content of the article, within each criterion.

[Insert Figure 1: Selection process of articles]

Results

[Insert Table 1: Extracted studies]

The 39 final articles were analyzed in accordance with the predetermined research questions. We structured the findings and results by first examining the types of data used in the studies. Next, we illustrated the results on the interaction between social network compositions and deviant influence. Finally, we focused on the transmission of deviant influence in adolescent networks.

The information used for the construction of adolescent social deviance networks

The data for all studies analyzed were collected by surveying adolescents through questionnaires or by conducting interviews. Notably, over one-third of the studies in this category (38.46%) used data from the Add Health study (US National Longitudinal Study of Adolescent Health) to draw conclusions about social networks and peer deviant influence. Additionally, almost 20% of the studies focused on data from the US-based PROSPER-project (PROmoting School-community-university Partnerships to Enhance Resilience) to construct their networks.

This consistency in the data collection processes was also reflected in the composition of the samples. All studies focused on adolescents who were mostly already in high school, with a range from 12 to 18 years old. Some studies – especially those using the PROSPER-data – included younger minors (e.g., sixth grade), but also used data from subsequent study phases from the same group in later years (e.g., McMillan et

al. 2018; Osgood et al. 2013; Ragan 2020; Rulison et al. 2015). The majority of the studies used samples with a predominantly White population, although some put more emphasis on ethnic minority groups (e.g., Dijkstra et al. 2010; Schreck et al. 2004). Furthermore, more than half of the studies showed a nearly equal sex distribution, while others only focused on boys or girls (Dijkstra et al. 2010; Mangino 2009; Stogner et al. 2014). Regarding the phenomenon type, a mixed measure of delinquency and deviant behavior was analyzed in almost half of the cases. In addition, approximately 15% of the studies examined school-related behavior such as school dropout, bullying, and academic achievement.

It is worth noting that all studies relied on self-reported information provided by the respondents. In most cases, adolescents were asked in a school context to identify a number of (best) friends to construct a social network (Baerveldt and Snijders 1994; Lakon et al. 2015; Rambaran, Dijkstra, and Stark 2013; Smith and Ecob 2013), which allowed for the examination of reciprocity (Wasserman and Faust 1994). However, some studies restricted friend selection to the same class (Knecht et al. 2010), the same grade, (McMillan et al. 2018; Rulison et al. 2015; Weerman 2011; Widdowson et al. 2020), or the same school (e.g., Chen, Thrane and Adams 2012; Duxbury and Haynie 2019; Ragan 2020).

Some studies used indirect measures of deviant behavior by asking respondents to report on peer deviant behavior (e.g., Dijkstra et al. 2010; Lin et al. 2018; Dupéré et al. 2021). An advantage of this approach is that it could uncover additional information that a person would not reveal about oneself, which could limit the social desirability bias (Lin et al. 2018). A disadvantage is that it is still subjective, nonconsensual information and the respondents' perspective (Copeland et al. 2019), which could result in respondents withholding incriminating information about their friends, being unaware of

certain behaviors (e.g., Chen et al. 2021; Weerman and Smeenk 2005; Young et al. 2011), or even exaggerating the deviant behavior of their friends (Young and Weerman 2013).

The impact of social network compositions of adolescent networks on deviant influence

While most studies used network structure measures with nodes and edges, Bayram Özdemir et al. (2018) and Smith and Ecob (2013) focused on social influence by measuring the similarity of criminal behavior between individuals and their friends. Moreover, few studies have primarily examined descriptive information such as the number of edges (Dupéré et al. 2021; Lin et al. 2018; Widdowson et al. 2020) and the group size (Rees and Pogarsky 2011).

Peer influence and popularity

Almost 25% of the studies have analyzed the popularity of the individual nodes (e.g., Dijkstra et al. 2012; Burt and Rees 2014; Stogner et al. 2014; Turanovic and Young 2016; Copeland et al. 2019). In addition, five studies have examined the Bonacich centrality (Copeland et al. 2019; Osgood et al. 2013; Reynolds and Crea 2015; Schreck et al. 2004; Stogner et al. 2014).

The influence of popularity and Bonacich centrality on deviant behavior in the context of peer influence has yielded mixed results across various studies. One study found that popular adolescents and adolescents with high social status were more likely to adopt delinquent and depressive behavior from their peers (Reynolds and Crea 2015). However, popularity could not explain peer influence in the case of runaway behavior, as adolescents with and without runaway episodes were equally popular (Chen et al. 2012). Popularity was also found to have a protective effect on self-harming behavior in adolescents due to their high integration in the network (Copeland et al. 2019).

Furthermore, popularity was not only associated with deviant or offending behavior but also with the victimization of adolescents. In one study, the popularity parameter increased the risk of sexual victimization in delinquent contexts, while the Bonacich centrality decreased it (Stogner et al. 2014). A similar result was found for violent victimization, where popular individuals in delinquent peer groups were more at risk (Schreck et al. 2004). However, when analyzing popular individuals in conventional groups, both the popularity parameter and Bonacich centrality had similar effects, which differed from Stogner et al. (2014).

Transitivity and reciprocity

Almost 40% of the studies focused on analyzing both the transitivity and reciprocity of adolescent social networks (e.g., Knecht et al. 2010; Lodder et al. 2016; van Zalk et al. 2010; Wang et al. 2017). These measures were used as control variables in statistical models to avoid overestimating peer influence effects (e.g., Dijkstra et al. 2010; Knecht et al. 2010). Substantively, the reviewed studies showed that social ties were often reciprocated (e.g., Osgood et al. 2015; Ragan 2020; Rambaran et al. 2013). However, reciprocity was more likely among best friends (Dijkstra et al. 2010) and among girls (Haynie, Doogan, and Soller 2014). Further, most studies did not elaborate on the transitivity, but one study on substance use found that diffusion of intervention effects was less likely in networks with a high transitivity ratio (Rulison et al. 2015).

Similarity

More than half of the reviewed studies focused on similarity between nodes, as a possible explanation for peer influence and selection effects. Researchers examined similarities in age (e.g., Duxbury and Haynie 2019; Lodder et al. 2016), gender (e.g., Knecht et al. 2010; Rambaran et al. 2013), ethnicity (e.g., Ragan 2020; Sentse et al. 2013), and behavior (e.g.,

Chang 2022; Dijkstra et al. 2010; Rees and Pogarsky 2011). However, the results of the interaction between similarity and peer influence and selection are inconsistent. While some studies found that delinquent adolescents do not tend to select friends with similar delinquent behavior (Weerman 2011), others have observed this effect of peer selection for several delinquent behaviors, such as substance use, general delinquency, and deviance (Gremmen et al. 2019; Knecht et al. 2010; Lodder et al. 2016; McMillan et al. 2018; Osgood et al. 2015; Sentse et al. 2013; Turanovic and Young 2016; Young et al. 2014; van Zalk et al. 2010). While gender did not seem to affect these selection effects (McMillan et al. 2018), a study suggested that the effects could depend on the degree of deviance within the network (Wang et al. 2017). Furthermore, one study proposed that delinquent adolescents may select and be drawn to peers based on their behaviors, rather than deviant behaviors spreading through influence (Chang 2022). The lack of selection effects in some studies (Weerman 2011) could be due to differences in the models and their underlying assumptions, leading to discrepancies in results (Young et al., 2014).

However, it is important to note that the inconsistent results across studies are complex and require nuanced interpretation. Knecht et al. (2010) found that gender similarity had a greater impact on friendship choice than delinquency did. Moreover, Gremmen et al. (2019) and Osgood et al. (2015) recognized that peer selection effects for delinquency were weaker than those for other behaviors, such as smoking and alcohol use.

The transmission of deviant influence in social networks of adolescents

Network distance and the strength of weak ties

Approximately 15% of the studies examined network distance to determine how far peer influence reached in the network (e.g., Baerveldt and Snijders 1994; Fujimoto and

Valente 2012; Rulison et al. 2015). Distance measures were used to examine the strength of weak ties in adolescent contexts. In two studies, the effect of peer influence for substance use (Fujimoto and Valente 2012) and delinquency (Payne and Cornwell 2007) persisted up to a distance of two steps, but decreased from three steps. This indicates that friends of friends can influence deviant behavior, but friends of those indirect friends (three steps away) are less significant for deviant influence. However, another study found that best friends were not more influential than remaining friends (Rees and Pogarsky 2011). Interestingly, all three studies used the same Add Health-dataset, but the first two studies focused on distance and did not specify the nature of the friendship (Fujimoto and Valente 2012; Payne and Cornwell 2007), while the third study looked at different intensities of friendships (Rees and Pogarsky 2011). A Dutch study compared best friends and 'regular' friends regarding deviant influence and found that best friends' delinquency levels matter more (Weerman and Smeenk 2005).

Bridging capacity of nodes in the network

Several studies have investigated the extent of bridging in social networks, using betweenness centrality as one metric (Copeland et al. 2019; Mangino 2009; Rulison et al. 2015). However, results on the relationship between peer influence and bridging positions have been mixed. Some studies have found that adolescents in bridging positions exhibit higher levels of self-harm due to their over-integration among peers (Copeland et al. 2019), while others suggest that occupying a bridging position can have a protective effect for African-American boys (Mangino 2009). However, the latter effect may be attributed to parental attachment rather than peer influence (Mangino 2009).

Researchers have examined the potential of bridging positions to facilitate the spread of attitudes and behaviors in the context of interventions in school and adolescent settings,

but results are conflicting. While some researchers suggest that bridges could be used to spread anti-smoking attitudes (Lakon et al. 2015), others argue that bridges do not hold influential positions since they are at the periphery of separate groups (Rulison et al. 2015), and may thus be less useful for interventions.

The potential of social network analysis to inform interventions was also explored in the context of behavioral diffusion (e.g., Osgood et al. 2013; Payne and Cornwell 2007; Rulison et al. 2015) and has been discussed since the end of last century (Baerveldt and Snijders 1994). Studies on substance use found that interventions targeting undirected edges and Bonacich centrality were more effective than those targeting betweenness centrality (Osgood et al. 2013). Moreover, cohesive networks were found to have a higher level of diffusion for substance use since students were connected with various peers through multiple pathways, while highly centralized networks were less ideal for the diffusion of behavior, as the most central individuals may control the spread of information through the network (Rulison et al. 2015).

Discussion

This article aimed to provide a critical overview of studies on deviant adolescent influence that apply a social network approach. We conducted an integrative review to achieve this, synthesizing knowledge from different research traditions. Despite carefully applying our selection criteria, two studies included in this review did not conduct a social network analysis (Bayram Özdemir et al. 2018; Smith and Ecob 2013). Nevertheless, various network measures were used in the studies that did construct social networks.

What information is used to construct social deviance networks of adolescents?

Regarding data collection, the included studies exhibited limited diversity in data sources as they were based on surveys and interviews, and the majority consisted of adolescent

samples in the United States from two datasets. Consequently, the generalizability of the findings to other adolescent populations (e.g., non-US countries) is limited. However, approximately 25% of the studies were based on European samples. Especially in the Netherlands, there is a larger focus on the use of social network analysis to study peer influence among adolescents (e.g., Knecht et al. 2010; Lodder et al. 2016; Rambaran et al. 2013; Weerman 2011; Young et al. 2014). These studies serve as a starting point and may inspire other criminologists to explore the use of social network analysis in studying adolescent peer influence.

The preference for surveys could be indicative of the difficulty in constructing rich social networks of adolescents with other data sources. Surveys allow for anonymous data collection (Reynolds and Crea 2015), which may limit the social desirability bias in respondents (Duxbury and Haynie 2019). Police registered data, for example, may suffer a dark number and contain fewer insights on relations and minor deviant behaviors of adolescents (Weijers and Eliaerts 2015). However, this difficulty in using police data could result from the operationalization of deviance and delinquency used in the studies. In most cases, delinquency or deviance involved rather minor offences or less severe deviant behaviors (e.g., substance use, vandalism). This seems to imply that adolescents are not involved in more severe crimes or behaviors, that are often captured in police databases. However, a limited number of studies did show that adolescents may engage in more serious behaviors such as violence (e.g., Haynie et al. 2014; Mangino 2009) and weapon carrying (e.g., Dijkstra et al. 2012). Therefore, future research using social network analysis could focus on other target populations and data sources – such as juvenile detention centers and police data – to examine whether the findings from existing studies generalize to other adolescent populations.

Moreover, deviance or delinquency among adolescents was often measured differently, which may contribute to less comparable results. One study may focus on alcohol use (Wang et al. 2017) or high school dropout (Dupéré et al. 2021), while another may focus on violent offending and victimization (Turanovic and Young 2016). Moreover, the results indicated variations in the utilization of either direct deviance measures or indirect measures among studies. This limits the comparability since the interpretation of deviance and perceived deviance can yield different conclusions (Young et al. 2015). Additionally, multiple acts or behaviors are captured in one measure of deviance. Hence, to determine which network properties play a role in the peer influence processes in specific deviant behavior of adolescents, future studies need to be transparent regarding their operationalization of measures and use clear concepts.

Lastly, restricting friendship nominations to in-school contacts may overlook certain peer influences, as a large proportion of adolescents' friendships may be situated outside the school (van Zalk et al. 2010). By only focusing on in-school relationships, contacts during leisure activities (Gremmen et al. 2019) and school dropouts (Chen et al. 2012) could be neglected.

How do social network compositions of adolescent networks affect deviant influence?

Self-reported friend nominations as links often result in directed social networks. The added value of such networks is that it allows additional measures to be examined, that cannot be used for undirected links. For example, the in-degree and out-degree can only be studied in directed networks (Tabassum et al. 2018). Moreover, the interpersonal process of reciprocity is also only observable between directed links (Tabassum et al. 2018; Wasserman and Faust 1994). Hence, the way the social ties are constructed – and the way the data are collected – can provide richer information regarding network

properties.

Concerning in-degree, the results on network compositions showed that being popular in adolescent networks or having many incoming links, can either have a protective or a reinforcing effect on deviant behavior, depending on the type of phenomenon. Moreover, the results on victimization could indicate that not only the type of phenomenon matters, but also the level of delinquency or deviance of the peer group influences the effect of popularity on victimization. The impact of social network compositions of adolescent networks on deviant influence is hence dependent on specific attributes or characteristics (i.e. behavior) of the nodes and edges in those networks.

The significance of personal characteristics was also demonstrated by the relationship between similarities of adolescents and deviant influence. From the studies, it was not always clear how these specific characteristics were correlated with influence on one's deviant behavior. Nevertheless, deviant influence effects can be confounded by selection processes that are in fact based on personal traits or influenced by the type of deviant behavior. One possible explanation for these discrepancies is that many of the reviewed articles utilize a broad definition of delinquency and deviance (e.g., Gremmen et al. 2019; McMillan et al. 2018; Payne and Cornwell 2007; Weerman and Smeenk 2005; Young et al. 2014), which encompasses minor deviant behaviors (e.g., smoking, graffiti) and more severe activities (e.g., fighting, weapon carrying). This conceptualization may have contributed to inconsistencies in the findings on peer influence and selection. Overall, the relationship between similarity, peer influence, and selection is complex and requires further investigation.

A number of studies also examined the out-degree centrality, but referred to this measure as density or out-degree density (Duxbury and Haynie 2019; Gremmen et al. 2019; Haynie et al. 2014; Osgood et al. 2015; Turanovic and Young 2016; Wang et al.

2017). However, the density of a network measures the overall level of edges within a network relative to the total number of possible connections, taking all the edges and nodes into account, and goes hence beyond the individual interactions (e.g., Chen et al. 2012; Dijkstra et al. 2012).

Lastly, almost all extracted studies focused on a more passive type of influence. More specifically, individual behaviors of adolescents and their friends were often examined separately to identify correlations between them. A few studies were exceptions and considered variables such as 'gang membership' (Smith and Ecob 2013) and 'membership of street-oriented youth group' (Weerman 2011). However, committing offences together or engaging in the same incidents can also impact future deviant behavior of adolescents (Andresen and Felson 2012). Therefore, future social network studies could explore whether specific behaviors are displayed in the company of certain nodes, and the nature of these network compositions. Subsequently, the effect of those interactions on the transmission of deviant behavior should be examined.

How is deviant influence transmitted in social networks of adolescents?

The transmission of deviant influence was primarily examined through distance measures and the bridging capacity of nodes. Distance-based results showed that proximity between nodes affected the amount of deviant influence, with transmission being more likely between socially closer nodes (Fujimoto and Valente 2012; Payne and Cornwell 2007). This suggests that having more contact with someone or the frequency of the contacts increases the probability of one's own deviant behavior being affected by that person. In addition, it suggests that superficial contacts may have less influence on adolescents' deviant behavior, and that greater social distance may act as a protective factor against the transmission of deviant behavior. Likewise, the quality of the

relationship between nodes or the strength of adolescents' friendships can impact the degree to which deviant behavior is transmitted (Weerman and Smeenk 2005). Here, differences in the operationalization of the concept 'best friend' could explain why best friends were sometimes more influential than regular friends, and other times not.

Finally, while it is often believed that nodes with a bridging position are crucial for the transmission of information (e.g., Golbeck 2015; Sparrow 1991; Tabassum et al. 2018), the extracted studies did not always report consistent findings. For interventions against the spread of substance use among adolescents, bridges did not seem to be ideal targets (Osgood et al. 2013; Rulison et al. 2015). It would hence be interesting for future research to explore the relationship between nodes' bridging capacity and peer influence for different types of deviant and criminal behavior. Similar results were found for the spread of the substance use itself, since the transmission of deviant influence was more likely in cohesive networks where adolescents' friends are also connected to each other, rather than indirectly linked through a bridge. This suggests that being part of closely connected friendship groups may facilitate the diffusion of deviant influence more effectively than being loosely connected to multiple groups.

Limitations

Although this integrative literature review adopted several criteria and standards, it faces limitations. First, a wide variety of phenomena could be detected, ranging from more innocent to severe deviant behaviors. It is possible that the predetermined selection criteria and search terms were not yet sufficiently refined, resulting in a lack of specificity and focus regarding behaviors across the extracted studies.

Another limitation is that we only focused on Scopus and Web of Science, despite the broader coverage of Google Scholar in certain academic fields (Halevi et al. 2017).

Hence, relevant articles may have remained undetected for this study. Google Scholar, however, lacks adequate quality control, and its results may contain duplicates (Halevi et al. 2017). The search focused on Scopus and WoS ensured that a feasible amount of quality articles was extracted.

Conclusion

In criminology, the framework of social networks is becoming increasingly important for the study of adolescent deviant behavior (Papachristos 2011). This integrative literature review has revealed that social network analysis is gaining traction in research on peer influence on delinquent behavior. However, some of the reviewed analyses lacked a robust methodology, while others failed to construct a proper network. The results of the first research question indicate that the analyses were mainly based on school-based surveys and were limited in their scope to a narrow range of deviant behaviors. To facilitate more comprehensive research on adolescent deviant behavior and enhance our understanding of social network influences, policymakers could consider making criminal data more accessible for research purposes. Expanding the availability of criminal data can provide researchers with a broader and more representative dataset, allowing for a more extensive analysis of deviant behaviors and their network properties. In turn, this accessibility could lead to more robust research findings. Ultimately, this will contribute to more effective prevention and intervention strategies for adolescent deviance.

The second research question showed that the results of different studies were not always compatible, leading to ambiguity regarding the impact of certain node positions or network compositions. In establishing policies and interventions, it is essential to consider that a one-size-fits-all approach may not always be the most effective choice.

Different deviant behaviors can result in various network patterns and have diverse effects, ranging from network positions being protective to reinforcing the behaviors.

The personal, social, and behavioral attributes should be considered in analyses, as they affect the extent of deviant influence. The results of the third research question suggested that attributes related to links also matter, and that the spread of deviant influence tends to diminish from a certain point. This indicates that direct and stronger contacts are more important for the spread of deviant influence. Law enforcement interventions can hence be targeted at these specific connections to fragment the network. However, this information is not only pertinent for disrupting deviance transmission, but can also be employed in the development of prevention strategies, including the dissemination of prevention messages.

To fill the research gaps identified in this literature review, future research could focus on applying network measures and interpreting the results in light of criminological theories and frameworks, such as social learning theories (e.g., Akers 1998) and social control theories (e.g., Hirschi 1969). Researchers could also be more explicit in recognizing the limitations of the data and methods used in their studies. Additionally, ethical and legal implications of mapping sensitive social networks need to be considered, given the possibility of indirectly identifying individuals without requesting consent (Cronin et al. 2021). By adopting these robust methodological strategies, researchers could yield more meaningful and far-reaching results.

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N°	Study	Type of data	Phenomenon	Tie definition	Network measures	Findings
1	Baerveldt and Snijders (1994)	Survey: Dutch schools	Petty crime	Self-reported friend nomination	Distance	Delinquent behaviour of friends influences one's own delinquent behaviour.
2	Bayram Özdemir et al. (2018)	Survey: Seven School Study Sweden	Ethnic harassment	Self-reported friend nomination	None	Prejudiced attitudes of friends influence one's own attitudes towards immigrant peers.
3	Burt and Rees (2014)	Survey: National Longitudinal Study of Adolescent Health (Add Health)	Substance use	Self-reported friend nomination	Popularity Ego centrality Density	Heterogeneity in peers' behaviours decreases the peer influence for substance use.

4	Chang (2022)	Survey: Taiwan Youth Project	Substance use, delinquency	Self-reported friend nomination	Density Distance Similarity	In the case of delinquency, the selection effect was bigger than the influence effect.
5	Chen et al. (2012)	Survey: National Longitudinal Study of Adolescent Health (Add Health)	Running away & minor deviance	Self-reported friend nomination	Popularity Degree centrality Density	Peer deviance was significantly associated with risk of running away.
6	Copeland et al. (2019)	Survey: PROSPER (PROmoting School-community-university Partnerships to	Self-harm	Self-reported friend nomination	Out-degree Popularity Bonacich centrality Bridges Reciprocity	Sociality and centrality were associated with lower self-harm levels, while bridging was associated with higher levels.

		Enhance Resilience) Project				
7	Dijkstra et al. (2012)	Survey: longitudinal study children and youth US	Weapon carrying	Self-reported friend nomination	Popularity Density Transitivity Reciprocity Similarity	Having friends who carry weapons increases one's own weapon carrying, while victimisation decreased the risk of this behaviour.
8	Dijkstra et al. (2010)	Survey: longitudinal study children and youth US, sampled for low SES Hispanic	Weapon carrying	Self-reported friend nomination	Out-degree Density Transitivity Reciprocity Similarity	Weapon carrying of adolescents is influenced by friends' weapon carrying through modeling and imitation.
9	Dupéré et al. (2021)	Interviews Canadian high schools	High school dropout	Self-reported	Number of edges	Adolescents were influenced by the dropout of intimates, but older occurrences were not associated with one's own dropout.

				deviance of friends		
10	Duxbury and Haynie (2019)	Survey: National Longitudinal Study of Adolescent Health (Add Health)	School punishment & academic achievement	Self-reported friend nomination	Density – out-degree Transitivity Reciprocity Similarity	Students who have been suspended maintain social ties with students who have a lower academic achievement.
11	Fujimoto and Valente (2012)	Survey: National Longitudinal Study of Adolescent Health (Add Health)	Substance use	Self-reported friend nomination	Distance Cohesion	Structural equivalence exposures were stronger than associations based on cohesion.

12	Gremmen et al. (2019)	Survey: longitudinal project SNARE	Delinquency, substance use, academic achievement	Self-reported friend nomination	Density – out-degree Transitivity Reciprocity Similarity	Both a selection effect and an influence effect could be observed.
13	Haynie et al. (2014)	Survey: National Longitudinal Study of Adolescent Health (Add Health)	Violent delinquency	Self-reported friend nomination	Density – out-degree Reciprocity Similarity	Girls were more vulnerable to peer influence by friends who are involved in violence.
14	Knecht et al. (2010)	Survey: longitudinal in high schools in the Netherlands	Delinquency	Self-reported friend nomination	Out-degree Transitivity Reciprocity Similarity	Adolescents select friends with a similar delinquency level.
15	Lakon et al. (2015)	Survey: National	Smoking	Self-reported	Out-degree Bridges	Peer influence had a protective effect on school smoking levels.

		Longitudinal Study of Adolescent Health (Add Health)		friend nomination	Transitivity Similarity	
16	Lin et al. (2018)	Survey: middle schools in China	Victimisation & aggressive behaviour	Self-reported deviance of friends	Number of edges	Victimised adolescents are more likely to have associations with delinquent behaviours, which influences their own aggressive behaviour.
17	Lodder et al. (2016)	Survey: high schools in the Netherlands	Bully victimisation	Self-reported friend nomination	Out-degree Density Distance Transitivity Reciprocity Similarity	Adolescents select friends with a similar victimisation level, but are also influenced by those friends.
18	Mangino (2009)	Survey: National Longitudinal	Serious delinquency	Self-reported	Density Bridges	African American social bridges were less delinquent because of the increased influence of their parents.

		Study of Adolescent Health (Add Health)		friend nomination		
19	McMillan et al. (2018)	Survey: PROSPER (PROmoting School-community-university Partnerships to Enhance Resilience) Project	Substance use, delinquency	Self-reported friend nomination	Out-degree Density Transitivity Reciprocity Similarity	The homophily in behaviours can be explained by both peer influence and friendship selection.
20	Osgood et al. (2013)	Survey: PROSPER (PROmoting School-	Antisocial attitudes and behaviour	Self-reported friend nomination	Degree centrality Bonacich centrality Betweenness	By using certain measures, the used interventions impacted the friendship networks in order to reduce the diffusion of problem behaviours.

		community-university Partnerships to Enhance Resilience) Project				
21	Osgood et al. (2015)	Survey: PROSPER (PROmoting School-community-university Partnerships to Enhance Resilience) Project	Delinquency & substance use	Self-reported friend nomination	Popularity Density – out-degree Transitivity Reciprocity Similarity	Adolescents prefer friends that are similar in behaviour and are strongly influenced by those friends.

22	Payne and Cornwell (2007)	Survey: National Longitudinal Study of Adolescent Health (Add Health)	Delinquency	Self-reported friend nomination	Distance	Peers had an influence on adolescents' delinquent behaviours up to two steps from those adolescents.
23	Ragan (2020)	Survey: PROSPER (PROmoting School-community-university Partnerships to Enhance Resilience) Project	Substance use	Self-reported friend nomination	Out-degree Density Transitivity Reciprocity Similarity	Peer influence decreases from early to mid-adolescence, but homophily in the substance use behaviours rises.

24	Rambaran et al. (2013)	Survey: The Arnhem School Study (longitudinal)	Risk attitudes	Self-reported friend nomination	Out-degree density Transitivity Reciprocity Similarity	Peer influence levels were similar at the classroom and at the school level.
25	Ramirez et al. (2012)	Survey: National Longitudinal Study of Adolescent Health (Add Health)	Intimate partner violence	Self-reported friend nomination	Degree centrality Density	Having violent friends in adolescence increased the risk of intimate partner violence perpetration in early adulthood.
26	Rees and Pogarsky (2011)	Survey: National Longitudinal Study of Adolescent Health (Add Health)	Delinquency	Self-reported friend nomination	Group size Similarity	The larger the group and the variation in delinquency levels, the more a best friend's influence decreased.

27	Reynolds and Crea (2015)	Survey: National Longitudinal Study of Adolescent Health (Add Health)	Delinquency & depression	Self-reported friend nomination	Popularity Bonacich centrality Density	Centrality, popularity and social status moderated the effect of peer influence on delinquency.
28	Rulison et al. (2015)	Survey: PROSPER (PROmoting School-community-university Partnerships to Enhance Resilience) Project	Substance use	Self-reported friend nomination	Bridges Distance Cohesion Transitivity	Diffusion was less likely in highly segregated networks and networks with a high transitivity ratio.

29	Schreck et al. (2004)	Survey: National Longitudinal Study of Adolescent Health (Add Health)	Violent victimisation	Self-reported friend nomination	Popularity Bonacich centrality Density	Network location and density increase the risk of violent victimisation.
30	Sentse et al. (2013)	Survey: longitudinal study children and youth US	Relational and physical victimisation	Self-reported friend nomination	Density Transitivity Reciprocity Similarity	Peer influence had an effect on relational victimisation, while peer selection is associated with physical victimisation.
31	Smith and Ecob (2013)	Survey: Edinburgh Study of Youth Transitions and Crime (longitudinal)	Broad and serious offending	Self-reported friend nomination	None	The peer influence effect on broad offending remains longer than for serious offending.

32	Stogner et al. (2014)	Survey: National Longitudinal Study of Adolescent Health (Add Health)	Sexual victimisation	Self-reported friend nomination	Popularity Bonacich centrality Density	Popularity was more associated with sexual victimisation in large delinquent groups than in smaller non-delinquent groups.
33	Turanovic and Young (2016)	Survey: National Longitudinal Study of Adolescent Health (Add Health)	Violent offending and victimisation	Self-reported friend nomination	Popularity Density – out-degree Transitivity Reciprocity Similarity	Homophily in violent offending and victimisation was related to peer selection and avoidance.
34	van Zalk et al. (2010)	Survey: Swedish schools	Depression	Self-reported	Transitivity Reciprocity Similarity	Adolescents select and de-select their friends based on similarities in drinking and delinquency.

				friend nomination		
35	Wang et al. (2017)	Survey: National Longitudinal Study of Adolescent Health (Add Health)	Alcohol use	Self-reported friend nomination	Density – out-degree Transitivity Reciprocity Similarity	Both peer influence and peer selection were associated with the levels of drinking.
36	Weerman (2011)	Survey: NSCR School Study	Delinquency	Self-reported friend nomination	Out-degree Density Transitivity Reciprocity Similarity	Similar adolescents do not seem to select each other as friends.
37	Weerman and Smeenk (2005)	Survey: NSCR School Study	Delinquency	Self-reported	Similarity	Both regular and best friends influence an adolescent's behaviour.

				friend nomination		
38	Widdowson et al. (2020)	Survey: PROSPER (PROmoting School-community-university Partnerships to Enhance Resilience) Project	Substance use	Self-reported friend nomination	Number of edges	Having delinquent friends was associated with substance use initiation, but the use of specific substances is not imitated.
39	Young et al. (2014)	Survey: NSCR School Study	Deviance (property offenses, substance use)	Self-reported friend nomination	Similarity	Adolescents select peers who are similar in behaviour.

Figure 1. Selection process of articles