

**THE INFLUENCE OF FRIENDSHIP NETWORKS ON ADOLESCENTS'
HEALTH-RISK BEHAVIORS: A SOCIAL NETWORK ANALYSIS**

A Dissertation

by

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Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

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December 2014

Major Subject: Health Education

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ABSTRACT

Friendships among adolescents can exert significant influence on behaviors that pose risk to their health. However, empirical evidence for friendships' influence is mixed due to various factors. Among these factors, are the complex mechanisms underlying friendship development (such as compliance with norms and beliefs that are encouraged and accepted by friends), as well as the use of traditional analytical methods for measuring the dynamic and complex mechanisms underlying the connection between friendships among adolescents and risky behaviors.

This dissertation addresses adolescents' health risk behaviors and the influence of friendship network structures on their risky behaviors, using Social Network Analysis (SNA) as an analytic tool. The dissertation comprises two studies: The first one comprises a systematic literature review, focusing on studies of the influence of friendship networks on adolescents' risky behaviors, which utilizes Social Network Analysis (SNA) and the Add Health data (a nationally representative sample). The review's findings indicated that, across the studies assessed, having friends engaging in risky behaviors is a negative predictor of adolescents' healthy behaviors. Moreover, the average methodological quality score (MQS) attributed to the reviewed studies was 4.5 (SD=1.4), an indicator of good quality (actual scores ranging from 2 to 7 points).

In the second study, we described the structure of friendship networks for adolescents who engage in, and for those who do not engage in sexual intercourse and alcohol consumption simultaneously. We also assessed the influence of the network's

structure upon adolescents' simultaneous sexual intercourse and alcohol consumption. Among the two schools examined in this study, out-degree and betweenness centrality functioned as significant predictors of increased engagement in sexual intercourse and drinking alcohol in tandem for School 1. Also for School 1, adolescents' age was associated with an increased risk for involvement in these simultaneous behaviors. In School 2, engagement in risky behaviors (sexual intercourse and alcohol consumption simultaneously) was significantly predicted by teens' age and gender, but there were no effects of network attributes on adolescents' risky behaviors.

Taken together, findings from these two studies contribute to better insights for developing intervention programs, especially programs targeting adolescents' friendship networks. Additional research also is warranted to examine how peer influences impact behavior over time (longitudinal studies), and how multi-level characteristics (e.g., intrapersonal or interpersonal) might interact with network structure variables to affect adolescents' risky health behaviors.

DEDICATION

This dissertation is dedicated to my father and family.

Thank you for all of your love and for believing in me.

ACKNOWLEDGEMENTS

This research uses data from the Add Health, a program directed by Kathleen Mullan Harris and designed by J. Richard Udry, Peter S. Bearman, and Kathleen Mullan Harris at the University of North Carolina, Chapel Hill, and funded by grant P01-HD31921 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development, with cooperative funding from 23 other federal agencies and foundations. Special acknowledgement is due to Ronald R. Rindfuss and Barbara Entwisle for assistance in the original design. Information on how to obtain the Add Health data files is available on the Add Health website (<http://www.cpc.unc.edu/addhealth>). No direct support was received from grant P01-HD31921 for this analysis.

I would not have completed this dissertation or my doctoral degree in Health Education at Texas A&M University, were it not for the guidance and support from my committee members. I would like to express my deepest gratitude to my advisor, Dr. Patricia Goodson, for her professional advice and knowledge, encouragement, and inexhaustible support academically and emotionally. I will always be very grateful to have been under her supervision during my academic life at TAMU.

I would also like to thank the committee members, Drs. Susan Ward, B.E. (Buzz) Pruitt, and Dominique Chlup, for their support and encouragement to complete my dissertation and degree. I am so thankful to all of you, for your valuable insights. I also

thank Dr. Verna M. Keith for her support and use of Race & Ethnic Studies Institute (RESI).

My road to academic achievement has been a long one filled with many emotions. I could never have completed this journey and degree without my family and friends. Many thanks to my close friends for constantly cheering and encouraging me. Last but not least, very special thanks to my father and family for your love, emotional support, and belief throughout this journey. I could never have obtained this degree without you all. I love you all.

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CHAPTER I

INTRODUCTION

The numbers of U.S. adolescents in grades 9 to 12 engaging in risky health behaviors have remained consistently high for more than a decade in the national data collected through the Youth Risk Behavior Survey (YRBS) [1]. In these data, for example, the proportion of youth declaring they had “ever had sexual intercourse” rose slightly from 46% in 2009 to 47.4% in 2011 [2]. The number of teens who answered positively to the item: “Ever had at least one drink of alcohol on at least 1 day during their life” decreased slightly to 70.8% in 2011, from 72.5% in 2009 [3], but even with these fluctuations, rates have remained high.

In addition to these high rates, adolescents face the reality that engaging in one risky behavior facilitates co-occurring risky behaviors. For instance, a study carried by Wu et al. found that if youth were engaged in unprotected sexual activity, they were more likely to become involved in other risky behaviors such as drug use and substance use at the same time [4]. Similar to the finding from Wu et al., the study conducted by Johnson et al. found that when adolescents engage in heavy alcohol use, they also engage in the co-occurring risky behavior tobacco use [5].

Risky behaviors can pose a threat to adolescents’ health. For instance, initiating sexual intercourse at an early age, coupled with having multiple sexual partners, is a key risk factor for contracting and/or transmitting sexually transmitted infections (STIs) [6]. Moreover, drinking alcohol may increase sexual risks, because alcohol consumption is often associated with unprotected intercourse.

When considering adolescents' risky health behaviors, a number of studies have shown that the relationships among adolescents may lead to increase in risk-taking, specifically the relationships among friends. For instance, the study conducted by Sieving et al. revealed that adolescents who had previously engaged in sexual behaviors exerted more influence on their friends to begin engaging in sex, than adolescents who had not engaged in sex [7]. Moreover, other studies have indicated that other types of risky behaviors (e.g., tobacco use or alcohol consumption) among adolescents also are frequently associated with friendships among peers [8-14].

Research in the social and behavioral sciences has utilized Social Network Analysis (SNA) as an analytic tool to understand the changes in adolescents' risky health behaviors as influenced by interactions with peers within friendship networks. Specifically, utilizing SNA is suited for measuring the complexities of network structures and relationships (linkages) among adolescents with risky behaviors, as SNA provides visual graphics of the networks and statistical measures that might be difficult to document through traditional analytical and statistical methods [15-19].

This dissertation, thus, addresses adolescents' health risk behaviors and the effects of friendship network structures on their risky behaviors, using SNA as an analytic tool. The text is organized into four chapters, and chapters II – III are formatted as journal manuscripts. This first chapter (Chapter I) introduces the study and organization of the overall manuscript.

Chapter II (first manuscript) presents results from a systematic literature review of friendship networks and adolescents' risky health behaviors in studies using SNA and

Add Health data^{*}. Specifically, the purpose of this review was to answer the following questions:

- 1) Which risky health behaviors have been examined using SNA and the Add Health data?
- 2) What findings have been identified in this literature (i.e., research using SNA and the Add Health data) relevant to friendship networks' impact on adolescents' risk behaviors?
- 3) What is the methodological quality of this body of literature?

Fourteen (n = 14) empirical studies were identified after applying specific inclusion/exclusion criteria, and became the final sample.

Chapter III (second manuscript) reports findings from a quantitative analysis. The analysis had two primary aims: 1) to describe the structure of friendship networks for adolescents who engage in, and for adolescents who do not engage in two risk behaviors simultaneously: sexual intercourse and alcohol consumption; and 2) to assess the influence of adolescents' friendship network structure upon their risky health behaviors (specifically the simultaneous behaviors of sexual intercourse and alcohol consumption). The first aim was achieved with the help of the NetDraw feature, found in UCINET, a network analysis tool. The second aim was achieved through logistic regression modeling.

Chapter IV summarizes the two studies, discusses their findings in tandem, and makes recommendations for future research and health education practice. One appendix

^{*} Description of the Add Health data in chapters II and III

is included in this dissertation: Appendix (alphabetized list of the studies reviewed in Chapter II).

CHAPTER II

**REVIEWING FRIENDSHIP-NETWORKS AND ADOLESCENTS' RISKY
HEALTH BEHAVIORS IN STUDIES USING SOCIAL NETWORK ANALYSIS
AND ADD HEALTH DATA**

Introduction

The report from the U.S. Youth Risk Behavior Survey (YRBS) has demonstrated trends in health-related risk behaviors among adolescents in grades 9 to 12 during 1991-2011 [1]. In the report, the number of adolescents who “had sexual intercourse with four or more persons (15.3%)” [2], and “used chewing tobacco, snuff, or dip on school property on at least 1 day (7.7%)” demonstrated a general increase [20]. On the other hand, the number of those who “ever had at least one drink of alcohol on at least 1 day” showed a slight decrease from 72.5% to 70.8% during that time [3].

Based on these trends, we ask: “What has caused these adolescents’ risky behaviors over time?” Researchers indicate that risky health behaviors among adolescents can be influenced by their peers or friendship relations [9,21-23].

Traditionally, literature in health risk behavior during adolescence has focused on individual adolescent risk taking behaviors as the unit of analysis; however, more recently, advanced analytical methodologies including Social Network Analysis (SNA), have led to the search for the patterns of health risk behaviors influenced by peer or social contexts (e.g., friendship networks and affiliations).

Studies have suggested that SNA has begun to be applied for an in-depth

understanding of the risky health behaviors among adolescents based on their relationships or interactions with other peers [24,25]. SNA is an optimal research tool because it maps out networks of relationships among different people in a social group context [26]. Therefore, SNA can help understand various risk behaviors that can be affected by other people [27]. Moreover, utilizing SNA a researcher is able to assess risky health behaviors of adolescents within peer networks and identify the structures of friendship ties that can influence behaviors.

In the U.S., for over a decade, researchers have studied peer effects upon adolescents' health risk behaviors using network structure data from the National Longitudinal Study of Adolescent Health (Add Health). The Add Health gathers data on adolescents' health risk behaviors from a stratified sample of high schools (grades 7 – 12) nationwide, thus generating representative data. Furthermore, the Add Health data focus on social contexts (i.e., friendships and family relationships) that influence adolescents' health-related behaviors [28]. Data are collected from in-school questionnaires and in-home interviews of adolescents, their peers, parents, and school administrators [28].

Researchers have analyzed Add Health data using social network analysis, demonstrating the effectiveness of the SNA method for assessing the structure of peer relationships or friendship networks [12,29]. These studies indicate that friendship ties and/or peer effects among adolescents can function as causal factors directly influencing peer's risk behaviors such as drinking and smoking. Also, peer influences affect behaviors either positively or negatively, depending on adolescents' perceptions of

friends' behaviors [7]. Despite its valuable contribution, research utilizing Add Health dataset varies in focus, with researchers examining many different types of friendships and various adolescent behaviors, such as drinking, tobacco use, and sexual intercourse.

The purpose of this study, therefore, is to answer the following questions through a systematic review of the extant literature: 1) Which risky health behaviors have been examined using SNA and the Add Health data? 2) What findings have been identified in this literature (i.e., research using SNA and Add Health data) relevant to friendship networks' impact on adolescents' risk behaviors? and 3) What is the methodological quality of this body of literature?

Systematic literature reviews contribute to an existing body of literature by organizing and assessing scientific findings to effectively demonstrate both the accuracy and reliability of evidenced-based information [30,31]. Given the advantages and contributions of systematic literature reviews, we employed this strategy to review the studies using Add Health data and focusing on adolescents' risky health behaviors, which utilize SNA as their analytic tool. A long term goal of this review is to provide assurance of the value in applying SNA as a method for studying adolescents' health-risk behaviors, and to assist future researchers/program planners in developing guidelines for implementing network-based intervention programs.

Background

National data, collected every two years by the YRBS and hosted by the Centers for Disease Control and Prevention (CDC) report that risky behaviors including tobacco use, drinking alcohol, and sexual activity have been health concerns for U.S. adolescents for approximately 20 years. Between 18 and 47% of adolescents in grades 9 through 12 use tobacco, drink alcohol, or are involved in sexual activity [1].

These behaviors are the main health challenges for adolescents because continued risky behaviors are associated with increasing health problems. Previous studies have indicated that smoking and drinking alcohol at an early age can lead to large numbers of young adults with poor health, an increased risk of alcoholism [32], and risks for chronic diseases (e.g., cardiovascular illnesses and cancer) [33]. Moreover, early sexual activity among adolescents can increase the risk of contracting sexually transmitted infections (STIs) [34] and the human immunodeficiency virus (HIV) [35].

In addition, researchers have reported that if adolescents are involved in a risk behavior, they have an increased likelihood of engaging in different risk behaviors *simultaneously*. A study carried by Johnson et al., for instance, identified a correlation between tobacco use and alcohol consumption among adolescents. Authors found adolescents who smoke are more likely to engage in binge drinking, simultaneously [5]. Likewise, adolescents used to drinking heavily are more likely to smoke at the same time.

Sexual behavior

Adolescents who engage in unprotected sexual behaviors have a considerably higher risk of experiencing an unintended pregnancy or contracting STIs, including HIV, than those who do not engage in these behaviors. As of 2011, the YRBS reported that the percentage of adolescents (grades 9 through 12) responding positively to the question “ever had sexual intercourse” was 47.4% [2]. Although this percentage is high, it represents a decline: in 1991, more than half (54.1%) of adolescents in grades 9 through 12 reported that they had engaged in sexual intercourse.

Another problematic sexual behavior, having had sexual intercourse before the age of 13, plateaued between 2001 and 2009 [2]. However, in 2011, the rates dropped by 4% (from 10.2% to 6%) compared to 1991 (see Figure 1).

Alcohol use

In the United States, alcohol use by adolescents remains a public health problem, and it is associated with different risk behaviors, including tobacco use and unprotected sexual intercourse. Data from the YRBS showed that, in 2011, an estimated 70.8% of adolescents reported they “ever had at least one drink of alcohol on at least 1 day (during your life)” [3]. This statistic shows the percentage fell by 11% compared to 1991.

By 2011, 38.7% of adolescents reported that they “had at least one drink of alcohol on at least 1 day (during the 30 days before the survey)” [3]. This percentage dropped from 50.8% in 1991, a 12% decrease (see Figure 1). It is important to bear in

mind that alcohol assumption among adolescents in the U.S. (under aged 21) is illegal [36].

Tobacco use

Smoking is related to morbidity and mortality, and is a leading cause of chronic diseases (e.g., cardiac disease and vascular disease). Data from the YRBS, in 2011, indicate that 44.7% of adolescents reported they “had tried cigarette smoking” [20]. This rate has fallen by 25% since 1991 (70.1%).

Another problematic smoking behavior among adolescents (i.e., “smoked cigarettes on a least 1 day”) when assessed in 2011, indicated 18.1% were smokers [20]. This rate has fallen by about 9.4% since 1991 (from 27.5%). While during the period 1991 – 1997 the rates had gradually increased to 36.8%, the numbers have since steadily decreased during the period of 1999 to 2011 (see Figure 1). Smoking among adolescents who are under the age of 18 years in the U.S. also is illegal [37].

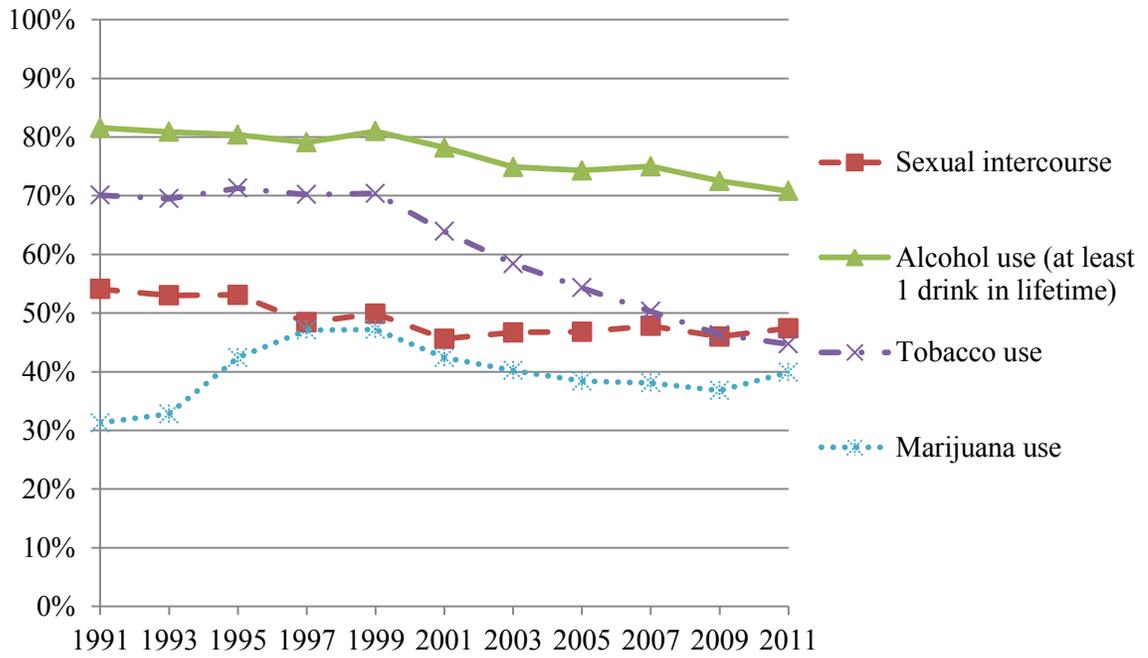
Marijuana and cocaine use

For adolescents, marijuana and cocaine use can cause unexplained changes in personality or attitudes such as anxiety, poor social skills, interpersonal alienation, and lack of impulse control. These substances also can affect their physical development (e.g., brain and nerve damage, respiratory problems, and blood pressure) [38-41]. Moreover, use of these substances can lead adolescents to engage in other risky health behaviors (e.g., sexual intercourse or drinking alcohol).

Although marijuana and cocaine use are illegal for adolescents [42] in the U.S*, data from the YRBS, in 2011, report 39.9% of adolescents using marijuana “one or more times” [43]. This rate has steadily increased by 8.6% since 1991. Between 1991 and 1999 the increase was even larger, from 31.3% to 47.2%. An estimated 6.8% of adolescents have reported they “ever used any form of cocaine one or more times” [43]. Moreover, from 1991 to 1999, the rates had slightly increased (5.9% to 9.5%) (see Figure 1).

* Recently, marijuana has been legalized in several states (e.g., California, Arizona, Washington, and Colorado) for medical and recreational purposes, and more states have enacted similar laws.

Figure 1. Trends in risky health behaviors among adolescents (grades 9 to 12) between 1991 and 2011(Data from the national Youth Risk Behavior Survey, CDC, USA) [2-3,20,43].



Methods

We adopted Garrard's Matrix Method to search the literature and qualitatively synthesize study findings [44]. We searched publications that specifically used the Add Health dataset, catalogued by the Inter-University Consortium for Political and Social Research (ICPSR) at the University of Michigan. However, because the search engine in the ICPSR was limited, it became necessary to identify reviewed articles through other electronic bibliographies also. We identified and retrieved, therefore, all peer-reviewed journal articles housed in three additional electronic databases (Medline, Eric, and PsycINFO), and detected through variations of MeSH terms combined with Boolean operators (e.g., sexual behavior, drinking behavior, adolescent, *and* social network, *or* network analysis). Additionally, we searched reference lists of the reviewed literature for other articles. Using the Scopus database, we conducted further searches based on the first or corresponding author names listed in the retrieved reports.

Searching databases for this review initially yielded 1,929 results. Of these results, 1,683 were identified in ICPSR, 42 in Medline, and 204 in Eric and PsycINFO. After identifying irrelevant topics and removing duplicates in an initial screening step, we identified 58 relevant studies. Among these, 46 studies were excluded based on our inclusion/exclusion criteria.

To be included in this review, studies needed to: (1) be published in a peer-reviewed journal between 2003 and 2013; (2) be written in English; (3) use SNA to study risky health behaviors; (4) focus on adolescents (aged 12 to 18 years old) in grades 7 through 12 (as these are the grades utilized in the Add Health data); and 5) utilize the

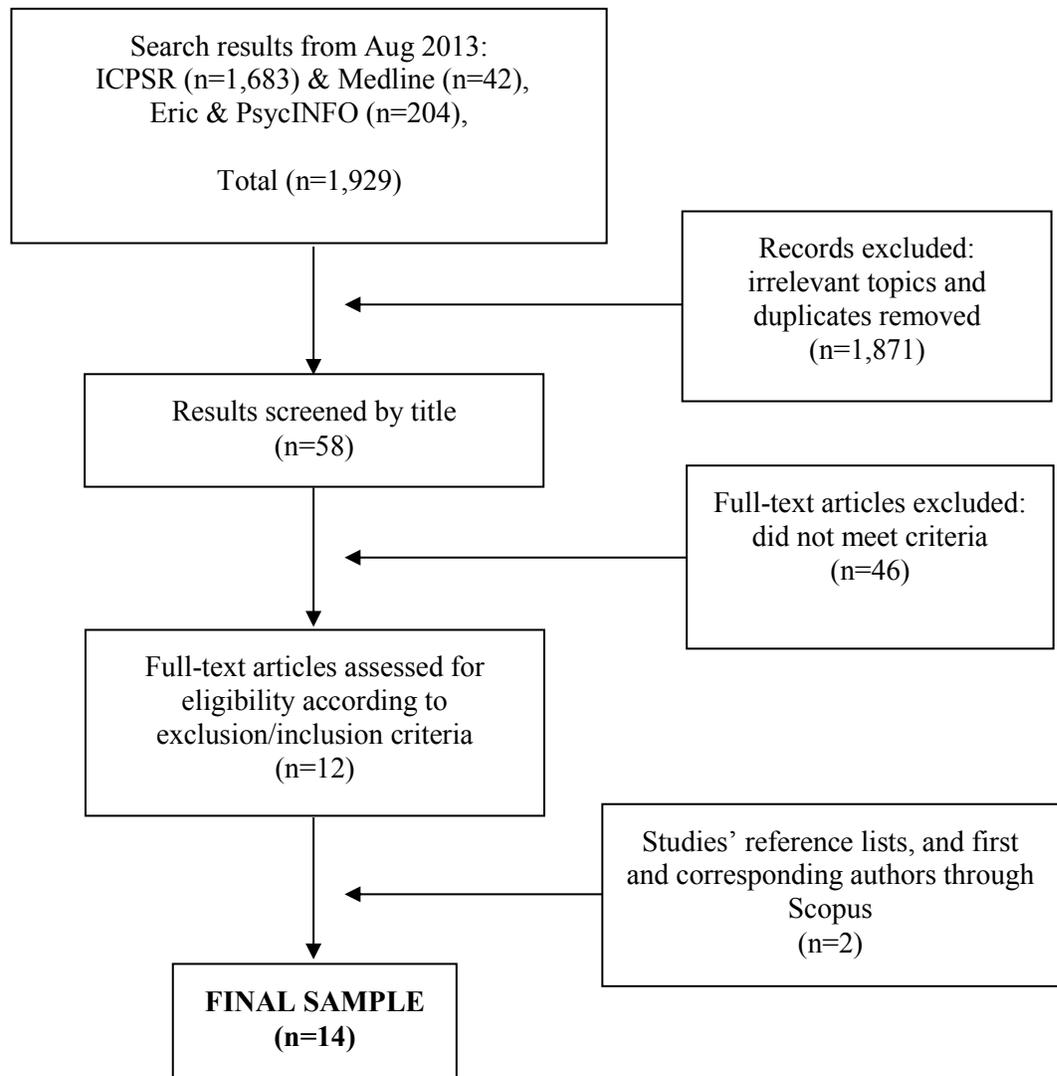
Add Health dataset. We excluded studies if (1) only abstracts were published; (2) articles did not use SNA to study adolescents' risky health behaviors; and (3) studies employed SNA, but did not utilize the Add Health data.

Thus, we identified 12 articles eligible for full-text review. Moreover, we retrieved 2 additional reports through retrieved studies' reference lists, and through first and corresponding author searches in Scopus. Of these two, one study was published in 2001, but we included it in this review, because it met our other criteria. Finally, 14 articles met our inclusion/exclusion criteria, and became the final sample in this review (see Figure 2) [45].

Subsequently, we employed a review matrix to organize the information extracted from each article. The review matrix (Table 1) included information for each study on: authors, sample, focal variables (type of behaviors studied), purpose of study, the use of theory, statistical analyses, type of network, key findings, and suggestion(s) for developing programs.

We assessed each article's methodological quality with criteria used in previous systematic literature reviews [21,46]. Each study received a methodological score, reflecting its performance on selected criteria. The criteria for the MQS are presented in Table 2, and include: whether studies examined a single or multiple risk behaviors; if studies utilized an established theoretical framework; if the report contained visualizations of the networks; if the report presented visualizations of the analysis; if the study tested specific hypothesis; if the report explained the types of data analysis employed; and whether researchers made recommendations for developing programs, based on their findings. The scores ranged from 1 to 9 with a higher value representing better methodological quality.

Figure 2. Flow diagram of reviewed articles*



* Note: Design adopted from the PRISMA Group proposal: Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med.* 2009;6(7):e1000097.

Table 1. Matrix of reviewed studies (by publication date)

Authors	Sample	Focal variable(s) (type of behaviors)	Purpose of study	Theory	Statistical analysis	Type of network		Key findings	Suggesting prevention /Intervention program
						Questionnaires	Type		
Alexander et al., 2001	• 2,525 at Wave 1 from Add Health	• Cigarette smoking	• “To investigate the effects of popularity, best friend smoking, and cigarette smoking within the peer networks on current smoking of seventh- through 12 th grade students”	• None	• Logistic regression	• During the past 30 days, on how many days did you smoke cigarettes? • During the past 12 months, how often did you smoke cigarettes?	• Ego	• “Having best friends who were cigarette smokers resulted in a twofold increased risk of current smoking (OR=2.00)” • “School smoking prevalence was positively associated with the odds of being a current cigarette smoker (OR=1.73). For every 10% increase in school smoking prevalence, there was a 73% increase in the likelihood of current smoking” • “There was a small but significant risk of being a current smoker for youth with higher levels of popularity and school smoking prevalence (OR=1.08)” • “The odds of current smoking were plotted against popularity for students with school smoking prevalence of 10%, a school with 25% smoking prevalence and one with a 40% smoking prevalence”	• None

Table 1. Continued

Authors	Sample	Focal variable(s) (type of behaviors)	Purpose of study	Theory	Statistical analysis	Type of network		Key findings	Suggesting prevention /Intervention program
						Questionnaires	Type		
Jaccard et al., 2005	• 1,692 at Wave I & II from Add Health	• Sexual activity • Binge drinking	• “To gain a sense of the magnitude of influence that close friends may exert on adolescent health-risk behavior”	• None	• Logistic regression	• Friend nominations: Did you go to [name]’s house during the past seven days?; Did you meet [name] after school to hang out or go somewhere during the past seven days?; Did you spend time with [name] during the past weekend?; Did you talk to [name] about a problem during the past seven days?; and Did you talk to [name] on the telephone during the past seven days? • Have you ever had sexual intercourse? • In what month and year did you have sexual intercourse most recently? • Over the past twelve months, on how many days did you drink five or more drinks in a row?	• Ego	• “Individuals who engaged in sex tended to have friends who engaged in sex and that individuals who engaged in higher levels of binge drinking tended to have friends who engaged in higher levels of binge drinking ($p < .05$)” • “The unstandardized regression coefficient for the peer predictor at Wave 2 was 0.12 (95% CI = 0.10 to 0.14, $p < .05$), suggesting that changes in the target’s binge drinking behavior over time are associated with changes in the binge drinking behavior of his or her closest friend over time, holding constant friendship selection effects” • “There was a statistically significant interaction with whether the friendship was reciprocated by the peer and peer binge drinking at Wave 2 (unstandardized regression coefficient for the product term = -0.09, 95% CI = -0.17 to -0.02, $p < .03$)” • “There was a statistically significant interaction with the stability of the friendship over time (product term coefficient = -0.07, 95% CI = -0.13 to -0.01, $p < .03$). When the friendship was stable between waves, the unstandardized regression coefficient for the peer Wave 2 binge drinking predictor was 0.07 (95% CI = 0.05 to 0.09), whereas when the friendship was unstable, the unstandardized regression coefficient was 0.15 (95% CI = 0.13 to 0.17). This result was counter to predictions, as it suggested weaker peer influence when friendships persisted across time”	• None

Table 1. Continued

Authors	Sample	Focal variable(s) (type of behaviors)	Purpose of study	Theory	Statistical analysis	Type of network		Key findings	Suggesting prevention /Intervention program
						Questionnaires	Type		
Sieving et al., 2006	• 2,436 at Wave I & II from Add Health	• Sexual intercourse	<ul style="list-style-type: none"> • “To examine forms and pathways of friend influence on adolescents’ sexual debut” • Four hypotheses: <ul style="list-style-type: none"> - “Adolescents with higher proportions of sexually experienced close friends are more likely to initiate sexual intercourse than others” - “Adolescents whose close friends hold positive attitudes related to sex have an increased likelihood of initiating intercourse” - “Close friends’ sexual behaviors and attitudes influence initiation of intercourse by influencing adolescents’ perceptions about gaining friends’ respect by having sex” - “The proposed associations are strongest among teenagers who are highly involved with their close friends” 	• None	• Logistic regression	<ul style="list-style-type: none"> • Friend nominations: Did you go to [name]’s house during the past seven days?; Did you meet [name] after school to hang out or go somewhere during the past seven days?; Did you spend time with [name] during the past weekend?; Did you talk to [name] about a problem during the past seven days?; and Did you talk to [name] on the telephone during the past seven days? • If you had sexual intercourse, your friends would respect you more. 	• Ego	<ul style="list-style-type: none"> • “The odds ratio (1.01) suggests that for every 1% increase in sexually experienced friends at Wave 1, the odds that young people initiated sex by Wave 2 increased by 1%” (p ≤ .001) • “The more respect adolescents perceived they would gain from friends by having intercourse, the higher their odds of sexual intercourse (odds ratio, 1.2)” • “Perceived respect from friends for having sex, the proposed mediator, was significantly associated with the proportion of sexually experienced friends (r=.07; p=.015) and with friends’ attitudes about sex (r=.14; p<.001)” 	<ul style="list-style-type: none"> • “interventions focused on delaying sexual intercourse among adolescents should address group norms for sexual behavior as well as the perceptions, skills and behaviors of individuals”

Table 1. Continued

Authors	Sample	Focal variable(s) (type of behaviors)	Purpose of study	Theory	Statistical analysis	Type of network		Key findings	Suggesting prevention /Intervention program
						Questionnaires	Type		
Clark et al., 2007	• 20,745 at Wave I & II from Add Health	• Cigarettes/Marijuana • Alcohol/Drunkenness	• “To empirically evaluate the proposition that risky behavior by adolescents depends on the behavior of their peers (here, other adolescents in the same school)”	• None	• Regression	• During the past 30 days, on how many days did you smoke cigarettes? & During the past 30 days, on the days you smoked, how many cigarettes did you smoke each day? • During the past 12 months, on how many days did you drink alcohol? & Think of all the times you have had a drink during the past 12 months. How many drinks did you usually have each time? • Over the past 12 months, on how many days have you gotten drunk or “very, very high” on alcohol? • During the past 30 days, how many times did you use marijuana?	• Ego	• “If participation in drinking alcohol by the male peer group in the same school year increases by 25%, the adolescent’s probability of drinking alcohol increases by 4.5%...” (p <.05) • “When the male peer group’s alcohol participation in the same school year rises by 25%, the male’s probability of drinking increases by 5.5%, with an analogous figure for females of 4.4%” (p <.05) • “For cigarettes, an analogous rise in peer smoking increases the adolescent’s probability of smoking by 2.2%...”	• Policy (i.e., cost)
Ali et al., 2009	• 20,745 at Wave I, II, & III from Add Health	• Smoking	• “To empirically quantify the role of peer social networks in explaining smoking behavior among adolescents”	• None	• Multivariate structural model with fixed effects	• During the past 30 days, on how many days did you smoke cigarettes?	• Ego	• “Having up to 25percentage of close friends as smokers increases the probability of smoking by 5% (.207/4), whereas being in a class containing up to 25% smokers increases the likelihood of smoking by 10%”	• Public health interventions
Pollard et al., 2010	• 6,696 at Wave I, II, & III from Add Health	• Tobacco use	• “To examine how friendship networks in adolescence are linked to tobacco use trajectories through a combination of analytic techniques that traditionally are located in separate literatures: social network analysis and developmental trajectory analysis”	• None	• Latent class growth analysis	• None	• Ego	• “Both perceiving that a greater number of one’s best friends smoked, and increases in the perceived number of best friends who smoked over a one-year period, were associated with greater odds of an adolescent being in one of the smoking trajectories compared to being a never smoker” (p <.05) • “Membership in a smoking group has these effects above and beyond the effect associated with the perceived number of best friends who smoke” (p <.05)	• None

Table 1. Continued

Authors	Sample	Focal variable(s) (type of behaviors)	Purpose of study	Theory	Statistical analysis	Type of network		Key findings	Suggesting prevention /Intervention program
						Questionnaires	Type		
Lakon et al., 2010	• 6,504 at Wave I from Add Health	• Smoking	• “To examine adolescents’ personal networks, school networks, and neighborhoods as a system through which emotional support and peer influence flow, and we sought to determine whether these flows affected past-month smoking at 2 time points, 1994–1995 and 1996”	• None	• Structural equation modeling	• During the past 30 days, on how many days did you smoke cigarettes? • Of your 3 best friends, how many smoke at least 1 cigarette a day?	• Ego	• “The popularity of adolescents (in-degree centrality) was affected both by their own past-month smoking and by their friends’ smoking behavior. A 1% increase in past month smoking increased in-degree centrality by 2.3% (b=0.023; P<.01)”	• School-based prevention programs • Self-regulatory techniques (e.g., journaling)
Ali et al., 2010	• 20,745 at Wave I, II, & III from Add Health	• Alcohol consumption	• “To empirically quantify the role of peer social networks in explaining drinking behavior among adolescents”	• None	• Multivariate structural model with fixed effects	• During the last 12 months, on how many days did you drink alcohol?”	• Ego	• “A 10% increase in close friends drinking will increase the likelihood of drinking by more than 2% (coefficient=0.238, p-value=0.000) and a 10% increase in drinking among grade-level peers is associated with a 4% increase in individual drinking (coefficient=0.446, p-value=0.000)” • “An increase in drinking among individual’s classmates by 10% will result in an increase in the likelihood of individual drinking and the frequency of alcohol consumption by approximately 4% (coefficient=0.405, p-value=0.005)”	• Policy interventions at the school level
Kreager et al., 2011	• 898 at Wave I & II from Add Health	• Drinking	• “To connect alcohol use, dating, and peers to understand the diffusion of drinking behaviors in school-based friendship networks” - “Test for the direct and indirect effects of partners and friends-of partners on individuals’ problem drinking, net of individuals’ prior drinking levels and the drinking of their immediate friends”	• None	• Hierarchical linear model	• Over the past 12 months, on how many days did you drink five or more drinks in a row? • During the past 12 months, on how many days did you drink alcohol? • During the past 12 months, how often did you get drunk?	• Ego	• “Connections with drinking partners, friends, and partners’ friends are all positively and significantly associated with future binge drinking. A standard deviation increase in (1) partner’s prior drinking increases respondents’ odds of binge drinking by 32 percent, (2) friends’ prior drinking increases the odds of binge drinking by 30 percent, and (3) friends-of-partner prior drinking increases the odds of binge drinking by 81 percent”	• None

Table 1. Continued

Authors	Sample	Focal variable(s) (type of behaviors)	Purpose of study	Theory	Statistical analysis	Type of network		Key findings	Suggesting prevention /Intervention program
						Questionnaires	Type		
Ali et al., 2011	• 20,745 at Wave 1 from Add Health	• Sexual behavior	• “To empirically quantify the role of peer social networks in influencing sexual behavior among adolescents”	• None	• Regression	• Have you ever had sexual intercourse? • Number of sexual partners	• Ego	<ul style="list-style-type: none"> • “A 10% increase in close friends initiating sex will increase the likelihood of engaging in sexual intercourse by more than 2% and a 10% increase in sexual initiation among grade-level peers is associated with a 4% increase in individual sexual initiation (p<0.01)” • “Peer initiation of sex and the number of sexual partners of peers is statistically significant for the nominated peers and indicates that a 10% increase in sexual behaviors will result in a 4.7% increase in individual behavior (p<0.01)” 	• Public health intervention

Table 1. Continued

Authors	Sample	Focal variable(s) (type of behaviors)	Purpose of study	Theory	Statistical analysis	Type of network		Key findings	Suggesting prevention /Intervention program
						Questionnaires	Type		
Mundt MP, 2011	· 2,610 at Wave I & II from Add Health	· Alcohol use	<ul style="list-style-type: none"> · “To investigate the association between adolescent social network characteristics identified in the previous studies, such as social status, social embeddedness, social proximity to alcohol users, and overall network interconnectedness, to adolescent alcohol initiation prospectively over time” - “Is social status, as measured by indegree, associated with adolescent alcohol initiation?” - “Is social embeddedness in the social network, as measured by centrality, linked to adolescent alcohol onset?” - “Is proximity to alcohol users, as measured by 3-step reach, correlated with adolescent alcohol inception?” - “Is overall network connectedness, as measured by network density, related to the start of adolescent alcohol drinking?” 	· None	· Generalized estimating equations	· Do you ever drink beer, wine, or liquor when you are not with your parents or other adults in your family?	· Ego	· “For every additional friend with high indegree, the likelihood that an adolescent initiated alcohol use increased by 13% (95% CI, 4%–22%). For every additional 10 friends within 3-step reach of a nominated friend, risk of alcohol initiation by a nondrinker increased by 3% (95% CI, 0.3%–6%). Risk of alcohol use onset increased 34% (95% CI, 14%–58%) for each additional friend who drank alcohol (p < 0.05)”	· None

Table 1. Continued

Authors	Sample	Focal variable(s) (type of behaviors)	Purpose of study	Theory	Statistical analysis	Type of network		Key findings	Suggesting prevention /Intervention program
						Questionnaires	Type		
Fujimoto et al., 2012	• 2,533 at Wave 1 from Add Health	• Drinking • Smoking	<ul style="list-style-type: none"> • “To Identify some of the features or types of friendships that are most likely to affect adolescent alcohol use and cigarette smoking by computing the level of exposure to friends’ behavior and their associations with individual behavior” • Three hypotheses: <ul style="list-style-type: none"> - “The first hypothesis is that influence from mutual friendships has stronger influence on adolescent drinking and smoking than non-mutual friendships” - “The second hypothesis is that the influence from friends that the adolescents admire (unreciprocated ego-nominating friend) has a stronger effect on adolescent drinking or smoking than the one from friends whom they do not nominate (unreciprocated alter-nominating friends)” - “The third hypothesis is that the influence from the best friend has a stronger effect on adolescent drinking or smoking than influences of the remaining friends on drinking and smoking behavior” 	• None	• Logistic regression	<ul style="list-style-type: none"> • During the past 12 months, how often did you get drunk? • During the past 30 days, on how many days did you smoke cigarettes? 	• Ego and alter	<ul style="list-style-type: none"> • “The effect from mutual friends (AOR= 2.07) on past-year drinking was slightly higher than exposures from outdegree-based unreciprocated alters (AOR= 2.02) or indegree-based unreciprocated alters (AOR=1.97) on past-year drinking (p < 0.001)” • “The effect of exposure from mutual friends on current smoking (AOR=4.44) was almost 1.6 times higher than the effects of exposure from outdegree-based unreciprocated alters (AOR=2.89) or indegree-based unreciprocated alters (AOR=2.73) on current smoking (p < 0.001)” • “The odds ratio for the mutual friendship (AOR=4.44) falls above the upper 95% CIs for both outdegree-(upper 95% CI= 3.96) and indegree-based (upper 95% CI=3.74) unreciprocated alters, which provides evidence that the differences in odd ratios were statistically significant (p < 0.001)” • “The effect of ego-nominating friends (outdegreebased influence, AOR=2.02) was a little bit higher than the effect of alter-nominating friends (indegree-based influence, AOR=1.97) on past-year drinking, and similar results with regards to the effect of directionality of friendship on current smoking (AOR=2.89 for outdegree-based influence and AOR_ 2.73 for indegreebased influence) (p < 0.001)” • “The magnitude of the effect of outdegree-based influence from alters regardless of reciprocation on past-year drinking (AOR=3.29) was much higher than the effect of influence from mutual friendship on past-year drinking (AOR=2.07) (p < 0.001)” • “The influence from the “best friends” was actually smaller than the combined influence of the remaining friends for past-year drinking (AOR=1.55 for best-friends influence and AOR=2.62 for the rest of the friends) (p < 0.001)” • “Classmates’ influence was significant for some types of friends’ influence at $\alpha = 0.05$ level for drinking outcome” 	• School-based substance use prevention programs

Table 1. Continued

Authors	Sample	Focal variable(s) (type of behaviors)	Purpose of study	Theory	Statistical analysis	Type of network		Key findings	Suggesting prevention /Intervention program
						Questionnaires	Type		
Fujimoto et al., 2012	• 12,551 at Wave 1 from Add Health	• Alcohol	<ul style="list-style-type: none"> • “To investigate the relative strengths of two network influences on adolescent drinking (and drinking frequency), derived from affiliation with organized sports/club activities with their friends, using the affiliation exposure model” • “To investigate how these different influence effects operate together as risk factors for adolescent drinking and drinking frequency, allowing us to disentangle overlapping influences from friend and nonfriend affiliates” 	• None	• Ordinal logistic regression	• During the past 12 months, on how many days did you drink alcohol?	• Ego and alter	<ul style="list-style-type: none"> • “The affiliation influence through sports had a significant effect on both any drinking and frequent drinking (adjusted odds ratio AOR = 1.20; $p < .05$). This result indicates that greater alcohol exposure to sports member drinkers leads to a higher likelihood of any drinking (or frequently drinking)” • “The influence through clubs had a significant effect on any drinking (AOR = 1.46; $p < .01$), but only a marginal effect on frequent drinking (AOR = 1.23; $p < .1$). These results indicate that adolescents exposed to drinkers in their sports or clubs were more likely to drink themselves, but the effect on frequent drinking was stronger in a sports context than in a club one” • “The friends’ exposure had a significant effect on both any drinking and frequent drinking (AOR = 1.55; $p < .001$), which indicates that adolescents with friends who drink were more likely to drink themselves” • “The affiliation influence through sports members who were also friends had marginal effects on any drinking and frequent drinking (AOR = 1.08; $p < .1$), but the affiliation influence through club members who were also friends had a significant effect on any drinking and frequent drinking (AOR = 1.15; $p < .01$)” • “The affiliation influence through nonfriend club members had a significant effect on both drinking behaviors (AOR = 1.37; $p < .01$)” • “The effects of affiliation influence through fellow sports members who were also reciprocated friends became significant for both any drinking and frequent drinking (AOR = 1.16; $p < .01$)” • “The results were similar to the ones based on nominated friends, but the effect’s magnitude for reciprocated-friends’ exposure decreased (AOR = 1.41; $p < .001$)” • “The magnitude of the effect through club members who were also reciprocated friends became larger and more significant (AOR = 1.22; $p < .001$) compared with the results of the nominated-friends’ affiliation model (AOR = 1.15; $p < .01$)” • “Affiliation influence through nonreciprocated friend club members was significant (AOR = 1.25; $p < .05$)” 	• School-based substance use prevention programs

Table 1. Continued

Authors	Sample	Focal variable(s) (type of behaviors)	Purpose of study	Theory	Statistical analysis	Type of network		Key findings	Suggesting prevention /Intervention program
						Questionnaires	Type		
Fujimoto et al., 2012	• 15,355 at Wave 1 from Add Health	• Drinking alcohol • Smoking	• “To investigate two contagion mechanisms of peer influence based on direct communication (cohesion) versus comparison through peers who occupy similar network positions (structural equivalence) in the context of adolescents’ drinking alcohol and smoking”	• None	• Logistic regression	• During the past 30 days, on how many days did you smoke cigarettes? • During the past 12 months, on how many days did you drink alcohol?	• Ego and alter	<ul style="list-style-type: none"> • “The odds ratios for cohesion exposure to drinking were significant for all distances, with the highest in magnitude at distance one (OR=1.57; p < 0.001), followed by distance two (OR=1.44; p < 0.001), distance three (OR=1.17; p < 0.01) and distance four (OR=1.16; p < 0.01).” • “The odds ratios for cohesion exposures to smoking were statistically significant up to distance two (but not significant for distances greater than two) with the highest in magnitudes at distance one (OR=1.50; p < 0.001), followed by distance two (OR=1.40; p < 0.001).” • “The odds ratios for structural equivalence exposure to drinking were statistically significant for all distances, with the highest in magnitude at distance one (OR=2.36; p < 0.001), followed by distance two (OR=2.30; p < 0.001), distance three (OR=1.90; p < 0.001) and distance four (OR=1.88; p < 0.001).” • “The odds ratios for the structural equivalence exposure to smoking”: “exposure effects were statistically significant for all distances with the highest in magnitude at distance one (OR = 1.99; p < 0.001), followed by distance two (OR = 1.83; p < 0.001), distance three (OR = 1.59; p < 0.001) and distance four (OR = 1.59; p < 0.001).” 	• School-based substance use prevention programs

Table 2. Methodological characteristics and frequency distribution of each criterion among 14 reviewed studies

Methodological Characteristic	Scoring options (maximum total score = 9 points)	Distribution of characteristics among 14 reviewed studies ^a	
		Frequency (n)	Percent (%)
Number of behaviors	Focused on two or more behaviors = 2 points	4	28.6
	Focused on one behavior = 1 point	10	71.4
Theoretical framework	Reported a scientific/ behavioral theory = 2 points	4	28.6
	Reported some theoretical explanation = 1 point	5	35.7
	Reported no theoretical framework = 0 point	5	35.7
Visualization of network	Provided visual graphs of network (in full or a sample) = 1 point	1	7.1
	Did not provide visual graphs of network = 0 point	13	92.9
Visualization of analysis	Provided visual graphs that help understand proposed analysis = 1 point	4	28.6
	Did not provide visual graphs that help understand proposed analysis = 0 point	10	71.4
Hypothesis testing	Tested a proposed hypothesis = 1 point	6	42.9

Table 2. Continued

Methodological Characteristic	Scoring options (maximum total score = 9 points)	Distribution of characteristics among 14 reviewed studies^a	
	Did not test a hypothesis = 0 point	8	57.1
Data analysis	Reported both descriptive and inferential statistics = 1 point	13	92.9
	Reported only inferential statistics = 0 point	1	7.1
Recommendations for developing programs	Makes recommendations for prevention/intervention programs = 1 point	9	64.3
	Makes no recommendations for developing programs = 0 point	5	35.7
Methodological Quality Score	Total possible maximum points = 9	4.5 (SD=1.4); actual range (2-7 points)	

^aThe frequency and percentages were calculated based on 14 reviewed studies.

Results

Studies' characteristics

Fourteen studies met our inclusion/exclusion criteria. Most studies (n=13) were conducted in the U.S., and one paper was authored by researchers in France. Most reviewed studies (n=10) were published between 2009 and 2012, perhaps because social network analysis only recently became popular as a research tool. Even though network data were collected in Wave I, 1994-1995, we found the earliest publication on social networks among the reviewed studies was published in 2001.

All reviewed studies appeared in journals with impact factors ranging from 1.48 to 4.422. Three of the fourteen studies were published in the *Journal of Adolescent Health*, and two studies were published in *Addictive Behaviors*. The other journals (the *American Sociological Review*, the *American Journal of Public Health*, *Health Psychology*, *Developmental Psychology*, *Social Science & Medicine*, *Academic Pediatrics*, the *Journal of Adolescence*, the *Journal of Health Economics*, and *Perspectives on Sexual and Reproductive Health*) published one report each.

Studies' findings

1) *Which adolescents' risky health behaviors have been examined using SNA and Add Health data?*

The studies in this review utilized SNA to examine adolescents' substance use — adolescents' drinking and smoking — and sexual behavior — specifically, sexual intercourse.

Eight studies examined adolescents' drinking or alcohol consumption behaviors [10,12,13,29,47-50]. Of these studies, each focused on different aspects of adolescents' drinking. Among these eight reports, six studied adolescents' *drinking frequency* as affected by best/close friends, peer group, affiliated members (e.g., sports and club activities), or direct/indirect friends [12,13,29,47,48,50]. Moreover, two studies carried out by Jaccard et al. [10] and by Kreager et al. [49] investigated adolescents' *level of drinking* (specifically, bingeing) as influenced by friends.

In the six studies focused on *drinking frequency*, researchers used various questions from the Add Health questionnaires, including: "During the past 12 months, on how many days did you drink alcohol?" and "Think of all the times you have had a drink during the past 12 months, how many drinks did you usually have each time?"; "Over the past 12 months, on how many days have you gotten drunk or 'very, very high' on alcohol?"; and "During the past 12 months, how often did you get drunk?". In the two studies examining *level of drinking* (specifically, bingeing), researchers used the following questions: "Over the past twelve months, on how many days did you drink five or more drinks in a row?" These questions were asked of adolescents and their friends.

Seven studies focused on cigarette use or smoking behaviors among adolescents [12,13,47,51-54]. All seven examined adolescents' *frequency of smoking* as influenced by various friendships, such as close/best friends, popular friends, mutual friends, or direct/indirect friends.

In these seven studies, authors used various questionnaire items, including: “During the past 30 days [past 12 months], on how many days did you smoke cigarettes?”; “During the past 30 days, on the days you smoked, how many cigarettes did you smoke each day?”; or “Of your 3 best friends, how many smoke at least 1 cigarette a day?”.

Three studies investigated sexual behavior (intercourse) [7,10,55]. These studies examined the *frequency of sexual behavior* as being influenced by close friends. Researchers used the questions: “Have you ever had sexual intercourse?”; “In what month and year did you have sexual intercourse most recently?”; or “If you had sexual intercourse, your friends would respect you more” from a section of “Motivations to Engage in Risky Behaviors” in the Add Health.

Even though the Add Health questionnaires have items addressing two different behaviors in tandem (e.g., sexual intercourse + drinking; and sexual intercourse + drugs), none of the reviewed studies examined more than one behavior at a time.

2) *What research findings have been identified in the literature relevant to friendship networks’ impact on adolescents’ risk behaviors?*

Drinking/Alcohol consumption

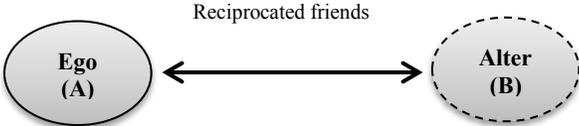
As mentioned previously, eight of the reviewed studies investigated the relationship between drinking alcohol and friendship networks (*drinking frequency and amount of drinking*). For instance, the study conducted by Fujimoto and Valente published in the *Journal of Adolescent Health* (2012) examined the influence of

friendship types on adolescents' substance use, including drinking (frequency) [12]. Authors classified three types of friendships: mutual friendships, directional friendships, and intimate friendships (see Figure 3). A mutual friendship was defined as reciprocated friends (knowing each other as friends). A directional friendship (see Figure 3) was defined as an unreciprocated nomination that originated either from an ego or from an alter (i.e., ego-nominating friend and alter-nominating friend). An intimate friendship was defined as closest/best friends who were being first nominated. These three types of friendships were based on friendship nominations that students were asked to make as they nominated five best male friends and five best female friends as part of the Add Health data.

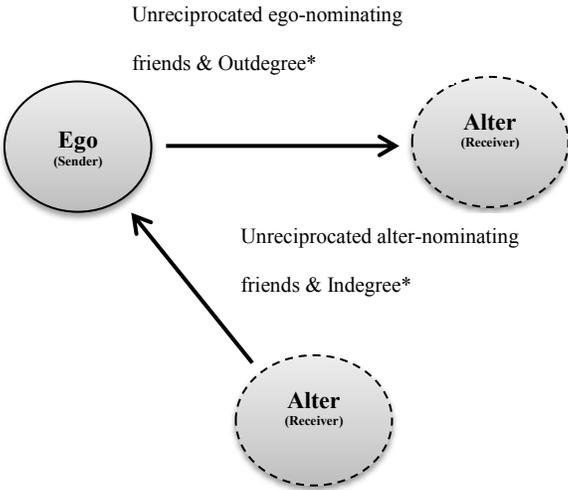
Authors found mutual friends were more likely to influence their friends' drinking behavior (frequency) than a directional friendship in the previous year ($p < 0.001$). Moreover, in the directional friendships among unreciprocated alters, the authors found ego-nominating friends (see Figure 3) were slightly more influential in adolescents' drinking behavior than alter-nominating friends ($p < 0.001$). Paradoxically, for the intimate relationships (see Figure 3), the study indicated that non-best friends were more likely to influence adolescents' past year drinking than best friends ($p < 0.001$).

Figure 3. Diagrams for three types of friendships

1) Mutual/reciprocated friendships

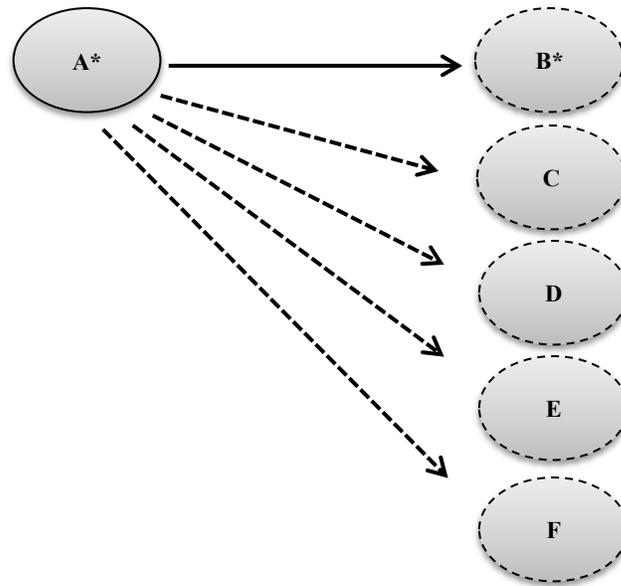


2) Directional friendships



* Outdegree is the number of friendship ties that the ego who is a focal point within a network “sends” and indegree is the number of friendship ties that the ego “receives” [9].

3) Intimate friendships



* B was nominated as *best* or *close friend* by A; C - F were nominated as friends, but not *best* or *close friends*.

The authors of this first study also examined — in a report published in *Health Psychology* in 2012—the influence on adolescents’ drinking (and drinking frequency) of friends and affiliated members in sports and club activities [50]. Adolescents were asked in which school-organized clubs or sports they participated. Based on this information, authors divided types of activities into 12 categories, such as playing chess, studying French and playing basketball. Moreover, researchers categorized friendships as 1) all nominated friends (adolescent nominated the alter as a friend, the equivalent to “directional friendships” in Figure 3), and 2) only reciprocated friends (both adolescents mutually called each other friends) (see Figure 3).

In the nominated friends’ general affiliation model*, sports members influenced adolescents’ drinking and frequency of drinking ($p < 0.05$), and only club members affected adolescents’ drinking ($p < 0.01$). This study additionally demonstrated that friends who drink were also more likely to affect adolescents’ drinking and drinking frequency ($p < 0.001$). In the nominated-friends’ affiliation model, this study indicated club members significantly influenced adolescents’ drinking and drinking frequency ($p < 0.01$). In the nonfriends’ affiliation model, club members who were not friends were more likely to affect drinking and drinking frequency of adolescents. In the reciprocated friends’ general affiliation model*, club members influenced adolescents’ drinking ($p < 0.001$), and sports members were more likely to influence adolescents’ frequent drinking

* Authors created affiliation models based on Nominated friends (i.e., General affiliation—the influence from all members’ friendships; Nominated-friends’ affiliation—the influence from adolescents who were nominated as friends; and Nonfriends’ affiliation—the influence from adolescents who were not nominated friends).

* Authors also created affiliation models based on Reciprocated friends (i.e., General affiliation—the influence from all members’ friendships; Reciprocated-friends’ affiliation—the influence from adolescents who had at least one reciprocated friend; and Nonreciprocated-friends’ affiliation—the influence of nonreciprocated friend).

($p < 0.05$). In the reciprocated friends' affiliation model, sports members who were mutual friends with adolescents significantly influenced drinking and frequent drinking ($p < 0.01$). Moreover, club members who were mutual friends were more influential in adolescents' drinking and frequency of drinking ($p < 0.001$) than the results based on nominated-friends affiliation model ($p < 0.01$). Additionally, in the nonfriends' affiliation model, club members significantly influenced drinking and drinking frequency of adolescents ($p < 0.05$).

Uniquely, this study showed that club members who have no friendship ties with others influenced other adolescents' drinking behavior within the friendship network based on affiliations. This finding can be explained by the fact that club members do not need to be intimate friends to be connected to each other, because they share many common interests and behaviors, even if they are not close friends.

In another study, Jaccard, Blanton, and Dodge evaluated how close friends influence adolescents' level of binge drinking. In this study, close friends were defined as those who were nominated by adolescents. Authors found a statistical significance in the behavioral similarity (binge drinking) between adolescents and their close friends ($p < 0.006$). Additionally, the study demonstrated that when adolescents' drinking behavior increased between Wave I (1995) and Wave II (1996) of data collection, their close friends' binge drinking also increased over time between Wave I and II ($p < 0.05$) [10].

The other five studies showed similar findings, indicating that friendships that matter, among adolescents, were more likely to exert influence upon adolescents' drinking behavior. For instance, among these five studies, one conducted by Clark and

Lohéac found that “if participation in drinking alcohol by the male peer group in the same school year increases by 25%, the adolescent’s probability of drinking alcohol increases by 4.5%”^{p773} [47]. Likewise, the study by Ali and Dwyer in 2010 showed that if the number of close friends who drink increased by 10%, other adolescents’ drinking would increase by 2%. Authors also found “a 10% increase in drinking among grade-level peers... associated with a 4% increase in individual drinking.”^{p340} [48].

Smoking/Tabaco use

Seven of the fourteen studies reported the influence of friendships on adolescents’ frequency of smoking. For instance, in a study carried out by Ali and Dwyer in 2009, authors categorized peer network as not only close friends who were nominated by the adolescents, but also those who were classmates and others from the same grade in school. A key finding from the study was that “having up to 25 percentage of close friends as smokers increases the probability of smoking by 5%... whereas being in a class containing up to 25% smokers increases the likelihood of smoking by 10%”^{p406} [52]. All these increases were statistically significant ($p < 0.01$).

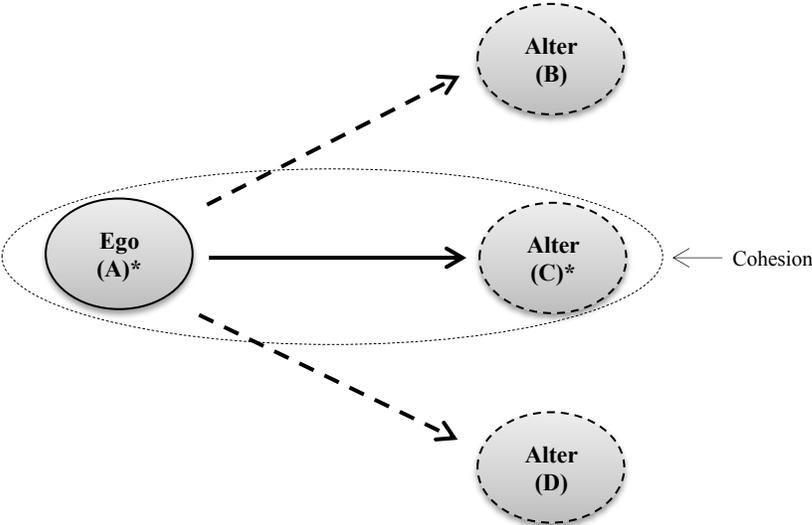
Another study by Fujimoto and Valente investigated the influence of peer networks on adolescent’s substance use (smoking cigarettes and drinking alcohol), based on contagion mechanisms, in terms of the cohesion and structural equivalence of the networks. Cohesion refers to relationships within a network, for which there are direct ties or exchange of influence. Structural equivalence referred to relationships among adolescents who occupy similar positions as others within friendship networks (Figure

4). Fujimoto and Valente defined peers as those who were nominated by friends. In their analysis, they utilized a network exposure model to assess both cohesion and structural equivalence measuring peers' risk taking in terms of social distances (at four steps away from other adolescents—friends of friends of friends of friends). The results indicated “the odds ratios for cohesion exposures to smoking were statistically significant up to distance two (but not significant for distances greater than two) with the highest in magnitude at distance one (OR = 1.50; $p < 0.001$), followed by distance two (OR = 1.40; $p < 0.001$)”^{p1957} [13].

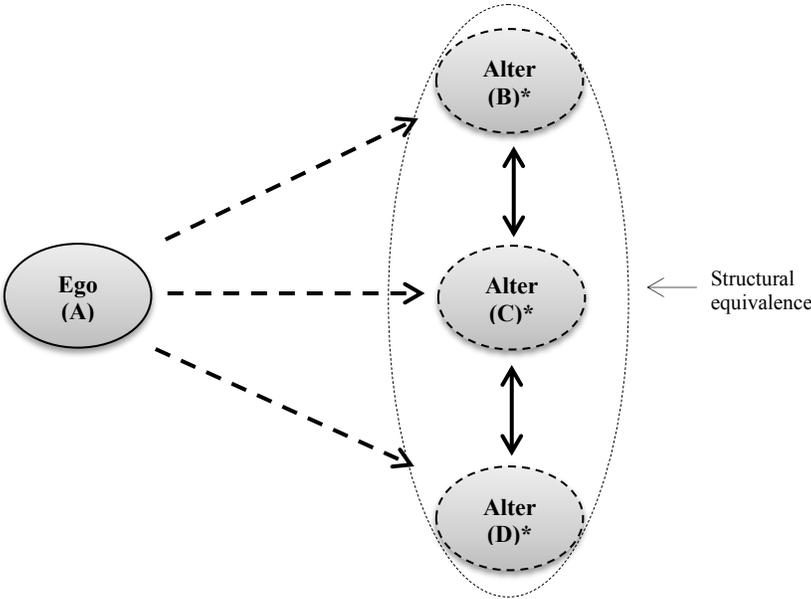
These findings suggest that direct or indirect friends (a friend or the friend of a friend) were more likely to influence adolescents' smoking behavior than friends at distance three or four (the friend(1)-of-a-friend(2)-of-a-friend(3), or the friend(1)-of-a-friend(2)-of-a-friend(3)-of-a-friend(4)) in terms of cohesion-related social distances.. Moreover, researchers found that for structural equivalence exposure to smoking, “...exposure effects were statistically significant for all distances with the highest in magnitude at distance one (OR=1.99; $p < 0.001$), followed by distance two (OR=1.83; $p < 0.001$), distance three (OR=1.59; $p < 0.001$) and distance four (OR=1.59; $p < 0.001$)”^{p1957} [13]. These findings suggest that adolescents, who are one and two steps away in the network structure, were more likely to affect adolescents' smoking behavior than adolescents at three or four steps away in terms of structurally equivalent social distances.

The other five studies showed similar results, namely, that various types of close friendships, such as best, popular, and mutual friends, were more likely to influence adolescents' smoking behavior than non-close friends. For instance, the study by Alexander et al. indicated that if adolescents have best friends who were cigarette smokers, those adolescents' probability of currently smoking increased by two fold [51]. Similarly, the study conducted by Pollard et al. demonstrated that "...a greater number of one's best friends [who] smoked, and increases in the perceived number of best friends who smoked over a one-year period, were associated with greater odds of an adolescent being [a smoker]..."^{p682} [53].

Figure 4. Diagrams for friendships in cohesion and structural equivalence



* C has a direct tie with A and is influenced by A. The relationships between A - B and A - D are not cohesive, because the ties are indirect and there is no exchange of influence.



* B - C and C - D are structurally equivalent ties, because the individuals occupy the same position in the network.

Sexual intercourse/Sexual activity

Three studies focused on how adolescents' friendships influence each other's sexual behavior (intercourse). For instance, the study by Sieving et al. investigated adolescents' sexual behavior as influenced by their close friends' attitude and behavior. In that study, authors classified close friends as those who were being nominated [7]. Close friends were based on friendship nominations by students who were asked to nominate best male and female friends. Researchers found that "...for every 1% increase in sexually experienced friends at Wave I [1995], the odds that young people initiated sex by Wave 2 [1996] increased by 1%"^{p17}.

Another study by Ali and Dwyer in 2011 examined the effects of peer groups on adolescents' sexual behavior. Authors defined peer group as not only close friends who were nominated by adolescents, but also those who were classmates and others from the same grade in school. In this study, they found that if the number of close friends initiating sex increased by 10%, an adolescent's probability of initiating sex would also increase by 5% [55].

The third study, by Jaccard, Blanton, and Dodge, showed similar findings, indicating that close friends were more likely to exert influence on adolescents engaging in sex. They found "of target individuals whose closest friends engaged in sexual activity across the two waves [Waves I and II in the Add Health dataset], 56% also engaged in sexual intercourse across the waves"^{p141} [10].

It is important to note that all reviewed studies examining risky behaviors examined individual behaviors; none examined two or more behaviors in tandem, such

as sexual activity coupled with alcohol consumption, or alcohol and tobacco use, for instance.

Methodological Quality of the Reviewed Studies (MQS)

We assigned a methodological quality score (MQS - with a possible range of 1 to 9 points) to each reviewed study. Table 2 presents the distribution of reviewed studies in terms of the MQS criteria. The average MQS was 4.5 (SD=1.4), with actual scores ranging from 2 to 7 points.

Ten reviewed studies (71.4%) focused on studying a single behavior (most commonly, smoking or drinking). Four studies (28.6%) studied two or more behaviors, such as alcohol and tobacco use, but each behavior was analyzed separately. None of the studies examined two or more co-occurring risk behaviors (e.g., sexual intercourse with drug or alcohol consumption).

Regarding using or adopting theoretical frameworks, while the majority (8 studies) employed a theoretical framework, six studies (42.6%) failed to do so. Of the 8 studies employing a theoretical framework, five (35.7%) provided some theoretical explanation/rationale and three studies (21.4%) presented a scientific or behavioral theory: Social Learning Theory and Social Comparison Theory. Eight studies (57.1%) did not test a hypothesis. Six reports (42.8%) tested a proposed hypothesis such as “influence from mutual friendships has stronger influence on adolescent drinking and smoking than non-mutual friendships” or “adolescents with higher proportions of

sexually experienced close friends are more likely to initiate sexual intercourse than others”.

Only one reviewed study (7.1%) provided visual graphics of the networks examined, while four studies (28.6%) provided illustrations of how friendships influence egos and their alters. Thirteen studies (92.9%) employed and reported both descriptive and inferential statistics in their data analysis. One study (7.1%) reported only inferential statistics. More than half of the reviewed studies (65%) made recommendations for prevention or intervention programs, based on their findings.

Discussion

This systematic review consolidated the current body of knowledge from relevant literature employing SNA for studying adolescents’ health risk behaviors. Specifically, we synthesized findings from network analyses based on the Add Health data, and assessed each report’s methodological quality (presented in Table 2).

In this review, fourteen studies met our inclusion/exclusion criteria. We found that, in general, various types of friendships exert influence upon adolescents’ health risk behaviors. Across reviewed studies, having friends engaging in risky behaviors is a negative predictor of adolescents’ healthy behaviors or a positive predictor of risky ones.

More than half of the reviewed studies examined data from Wave I and II from Add Health for the effect of friendship networks on adolescents’ risky behaviors at a single point in time, or over time. Based on these studies, we learn that individuals who have friends or are linked to friendship networks exhibiting risky behaviors (e.g.,

smoking or alcohol consumption) are at increased risk for engaging in these behaviors either initially or over time.

These findings from the Add Health dataset are similar to results from a longitudinal study using a sample in Finland. Mercken et al. assessed the relationship between substance use (alcohol consumption) and friendship networks among Finnish adolescents through different data points (i.e., time 1, time 2, time 3, and time 4). The result demonstrated that friends with risky drinking behaviors influenced adolescents to engage in similar drinking behaviors over time (between time 1 and 2) [14]. These results indicate, therefore, that SNA can account for the role of time in risky behaviors with more nuanced information than traditional longitudinal designs [56].

The reviewed studies, moreover, highlighted that the use of SNA can contribute to a better understanding of the complex mechanisms underlying the connection between friendships among adolescents and risky behaviors. Even studies that utilize SNA, but are not included in this review claim SNA is a helpful tool for understanding adolescent behaviors as an outcome of social relationships, as well as for understanding changes in behaviors and/or friendship networks over time [27,57-59], because friendship ties and behaviors occur inside the structure of dynamic interpersonal relationships among adolescents [60]. For instance, adolescents may choose friends having similar behaviors as theirs, or they may change their behaviors to develop new friendships or to match the behavior of existing friends. SNA, thus, can help explain peer selection, as well as lead to constructing models of changes in behaviors as a function of ties over time [15,58,59].

In addition, SNA also allows better understanding of phenomena that cannot be adequately studied with traditional linear analyses. In particular, linear analysis cannot provide measures of structural linkages of individuals located inside a network, as a supplement to empirical (linear) measures of individuals' health risk behaviors. Using SNA, however, researchers are able to account for, and examine network dynamics and structure (e.g., density and degree*) [16], the impact of a network structure upon health behaviors, as well as the role of individuals as a function of their placement in the network. Moreover, SNA can create visualizations, depicting ties among individuals [15,16], showing how an individual's position may act as a mediator for positive or negative behavioral influences. For instance, a study carried by Kreager and Haynie in the reviewed studies found that "indirect ties to a drinking peer through a romantic partner are associated with significantly higher future drinking than is the drinking of more proximal friends or romantic partners"^{p756} [49]. In other words, romantic partners as mediators can potentially influence other friends in the network to drink.

When SNA is employed in the study of health behaviors, it can not only identify structural and/or relational factors associated with behavioral changes in individuals or groups, but also provide information that can be used for developing effective network intervention programs to reduce health risk behaviors. In a study conducted by Valente et al., for instance, authors compared changes in adolescents' substance use (i.e., cigarette, alcohol, marijuana, and cocaine) between a control group receiving an

* Density is the number of actual connections as a function of the total possible connections in a network. Degree is the number of ties (in and out) with other individuals in a network.

evidenced-based prevention program and a network group receiving peer-leader intervention as a network prevention program [61]. The results indicated that using a peer-leader program targeting the network was more effective in reducing substance use after a one-year follow-up assessment.

When assessed for overall methodological quality, the mean MQS for the studies reviewed herein was 4.5, an indicator of good quality relative to our seven criteria (a theoretical range of 1–9 points). Although the body of evidence we reviewed exhibits good methodological quality, as scores fell above a theoretical mid-point of our scale, not supplying illustrative visualizations showing the connections among individuals in networks, the absence of theoretical frameworks, and not examining two or more behaviors in tandem, affected the overall quality of this body of research, vis-à-vis our criteria.

One common weakness was the absence of either graphs depicting the networks or visualizations that could help understand the proposed analyses. Providing graphical visualizations can improve the clarity of, and highlight structural relationships within networks [17]. For instance, the study carried by Mundt depicted a visual network of alcohol initiators and alcohol abstainers from their sample [29]. This graphical visualization can help us not only understand the relationship between these adolescents with the use of lines, but can guide us to a better understanding of network measures (e.g., density or degree). For instance, if a visual graphic displays higher dense network than sparse network, we can predict high density and degree on dense network.

Another methodological weakness we identified was the reviewed studies' lack of a theoretical framework to examine adolescents' risky behaviors. Although authors from the reviewed studies do not use any health behavior theories (or even refer to them briefly), they could have used social network theories to explain the influence of friendship on adolescents' behaviors.

The absence of a theoretical framework in research can lead to overlooking of salient factors and examining spurious ones. Conversely, using a theoretical framework can facilitate identifying possible causes [62,63]. Theory helps to develop programs, and findings from studies that use theory can be useful for determining the type of intervention that best suits risky behaviors and for developing more effective prevention programs that target risky behaviors among adolescents. Understanding of social networks is growing, based on the increasing amounts of data being collected. Nonetheless, in order to develop effective interventions that target adolescents' networks, theoretical explanations of the mechanisms affecting behaviors within a network become even more important. Using available theories of networks, adolescent development, and structural influences on behavior, researchers can shed light into the data they are now collecting and, over time, build the knowledge-base on this topic.

A further weakness was the absence of examining more than one behavior simultaneously. Studies focusing on two or more behaviors in tandem would allow for a better holistic understanding of the role of friendship networks in the dynamics of adolescents' risky behaviors, given that risk behaviors rarely happen in isolation. There is abundant evidence documenting adolescents' engagement in multiple risky behaviors

carried out simultaneously. The reviewed study conducted by Cooper, for instance, revealed that college students who drink alcohol were also involved in having sexual intercourse [64]. Similar to the finding from Cooper, a study from Johnson et al. also identified that when teens engage in high levels of alcohol consumption, they also were more likely to smoke [5].

Despite its contribution to the body of knowledge on friendship networks and adolescents' risky behaviors, this review carries a few limitations. First, even though we attempted to locate all studies employing SNA with the Add Health data, it is possible our search did not capture all existing studies, given we limited the search to published reports. Second, to assess the methodological quality of this literature, we adopted and created the MQS criteria based on previous systematic reviews. The precise criteria we use in this review, therefore, have not been tested for their ability to generate valid and reliable assessments and could, therefore, be biased.

In spite of such limitations, this systematic review demonstrated the important role of friends and friendship networks on adolescents' risky behaviors and the benefit of a SNA approach for better understanding of this role and its complex mechanisms. Identifying how friendships and/or friendship networks function as pathways for adopting risky behaviors can also help design guidelines for network intervention programs to reduce adolescents' risky behaviors.

CHAPTER III

ALCOHOL AND SEX: THE INFLUENCE OF FRIENDSHIP NETWORKS ON CO-OCCURRING RISKY HEALTH BEHAVIORS OF U.S. ADOLESCENTS

Introduction

In the United States, the national Youth Risk Behavior Survey (YRBS) has documented that 9th – 12th grade students in high school have engaged in many risky health behaviors. According to the YRBS data from 2011, 70.8% of teenagers reported having consumed at least one alcoholic drink [3]. Moreover, 47.4% of adolescents had engaged in sexual intercourse [2]. These two behaviors (i.e., alcohol use and sexual intercourse) occur more frequently among adolescents than other risky behaviors, such as tobacco use (44.7%) [20] or marijuana use (39.9%) [43]. In addition, in the same year, 22.1% answered positively to the item: “Did you *drink alcohol* or use drugs before you had *sexual intercourse* the last time?” — indicating that nearly half of the adolescents who engaged in sexual intercourse, did so under the influence of drugs or alcohol [2].

Risky behaviors among adolescents are a significant threat to their health during the adolescence years, yet engaging in risky behaviors can lead to non-trivial health problems, even as adults [65]. Certain levels of alcohol consumption during adolescence can negatively affect physiological development (by affecting the brain and hormones, for instance), and can lead to other risky behaviors, including unprotected sexual activity and tobacco use [6,66]. Although engaging in sexual activity during adolescence is normative within many social groups in the US [67], beginning sexual intercourse at an

early age leads to an increased risk for contracting or transmitting sexually transmitted infections (STIs), or for becoming pregnant [68]. These risks may increase when sexual activity is coupled with significant amounts of alcohol consumption [69], because high blood-alcohol levels can impair judgment and lead to unprotected intercourse.

The literature on adolescents' health addresses the notion that when adolescents engage in a risky behavior, they are more likely to engage in other risky behaviors. For instance, in a study conducted by MacArthur et al. [70], the authors documented that alcohol use among adolescents (aged 15 and 16) was positively associated with other risky behaviors (i.e., substance use, sexual activity). Additionally, the study by Patrick and Schulenberg presented adolescents' substance use (i.e., smoking and marijuana use) as leading to greater intentions to drink alcohol [71].

For these phenomena, earlier literature demonstrate that, in particular, friends and/or friendship networks during adolescence play a key role in influencing adolescents' risky behaviors (see Chapter II) [7,8,51,53], because friends and friendships underlie person-to-person and/or group-to-group interactions. For instance, the study conducted by Schwinn and Schinke found that drinking and offering alcohol increasingly affected other teens' intentions toward drinking [72]. In addition, in a study by Fujimoto and Valente, the authors addressed a key finding that various types of friendships among adolescents (i.e., mutual, reciprocal, and directional friendships) strongly influenced friends' substance use (e.g., drinking, smoking) [12]. Moreover, other studies have identified friendships as probably the most significant factor in the spreading of risky behavior among groups of teens [10,13,55], because of adolescents'

development and most of them needing to belong to their friends or other social groups outside their own family. Therefore, examining friendship networks may provide better information on adolescents' behaviors and their interpersonal mechanisms, than the study of individual intra-personal factors alone.

One way to capture the influence of friendships among adolescents is Social Network Analysis (SNA). Studies have highlighted that SNA can be applied to understanding the scope of changes in risky health behaviors and friendship ties among adolescents, because friendship networks and behaviors occur inside dynamic interpersonal systems. Specifically, utilizing SNA can provide visuals (in graph form) that are useful to describe and analyze the patterns of a network's structure, as well as verify statistical measures [17].

The theoretical perspective of network theory focuses on structural and/or relational approaches to the research of social (network) influence [73], compared with learning and/or observing approaches in traditional theories. In other words, network theory is based on the notion of network influence in that adolescents are affected by directly and indirectly interacting with their friends or with their friends' friends [74]. The result is that they can share similar behaviors (i.e., influence by friends or exert influence on friends) or hold similar positions in the networks (i.e., individuals connecting to all other friends in the network measured by network centralities such as degree [the number of links to and from a person], density [the ratio of the number of actual connections divided by the total possible connections in the network], and betweenness [the number of times an adolescent lies on the shortest paths linking other

adolescents in the network] [16]. Therefore, network analysis can facilitate examining the network composition of adolescents engaging in risky behaviors.

Traditionally, risky behavior dissemination relies on individual-level information related to how adolescents adopt a behavior through learning and/or observing others perform the behavior. Researchers have used traditional theories such as the Theory of Planned Behavior or Social Cognitive Theory in studies of health and risky behaviors among adolescents. These classical theories have emphasized the individual-level interpersonal process of learning risky behavior by directly observing how others behave, or by adopting a group's social norms and framing attitudes according to these norms in order to be accepted into the group [75].

Regarding our topic of interest, here, in addition to social network theory, Jessor's Problem Behavior Theory (PBT) can also help explore the mechanism of influence of friendship network structure upon adolescents' risky behaviors. PBT is based on a social-psychological framework that attempts to explain risk factors related to adolescent involvement in various problem behaviors such as sexual intercourse, tobacco, alcohol, and drug use [76]. PBT includes three major systems of socio-psychological variables: the personality system (i.e., individual values, beliefs, and attitudes), the perceived environment system (i.e., family and friend influences), and the behavior system (i.e., drinking, deviant behavior, marijuana, cigarettes, and drug use behaviors). According to Jessor, adolescents' problem behaviors are associated with the perceived environment system (e.g., peer relations) and personality system (e.g., attitudes), because, within peer relations, friends' behaviors can directly influence

various risky behaviors of adolescents [76].

Informed by these theoretical perspectives, the purpose of this study, therefore, is twofold: using data from a large, representative sample of adolescents in the U.S., to 1) describe the structure of friendship networks for adolescents who engage in, and for adolescents who do not engage in sexual intercourse and alcohol consumption simultaneously; and 2) assess the influence of friendship network structure upon adolescents' risky health behaviors (specifically the behaviors of sexual intercourse and alcohol consumption in tandem). To achieve this purpose, we employ SNA techniques, which utilized by authors in the research of social networks [24,26,57].

This study is important because it examines two risky behaviors simultaneously, while most previous studies examine a single risky behavior in isolation. We believe that research examining multiple simultaneous risk behaviors can significantly help with the design of more effective prevention programs that promote adolescents' healthy development.

Methods

Data source

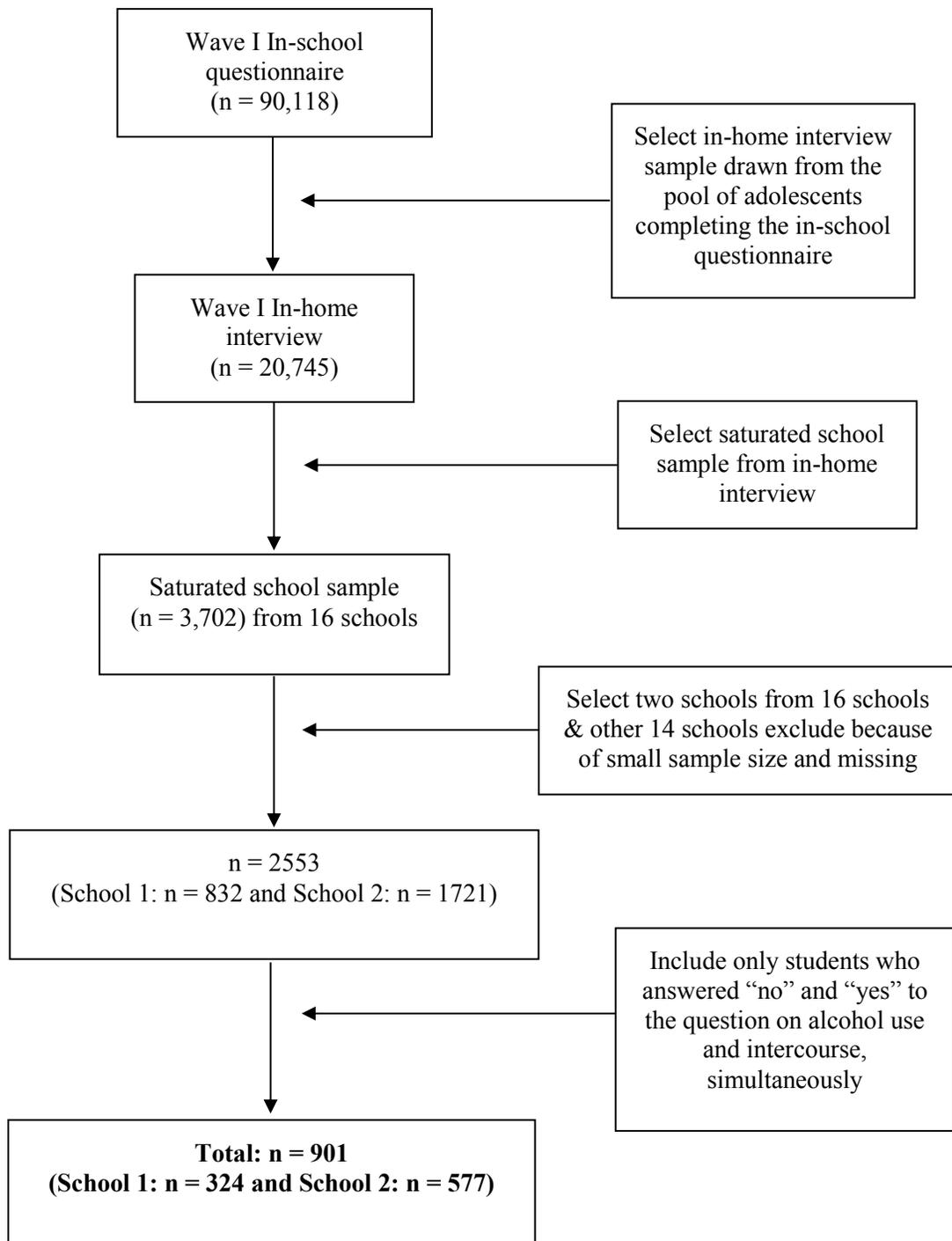
This study utilized the longitudinal data generated by the National Longitudinal Study of Adolescent Health (Add Health) in the United States. The Add Health study gathers information (e.g., health-related behaviors of adolescents, demographics, and family socio-economic status) for students in grades 7 through 12 nationwide, thus yielding representative data stored in the Inter-University Consortium for Political and Social Research (ICPSR). To date, Waves I, II, III, and IV of the data collection conducted in 1994-1995, 1996, 2001-2002, and 2007-2008, respectively, have followed youth from adolescence to young adulthood. The Add Health dataset comprises completed in-school questionnaires and in-home interviews. The Wave I in-school questionnaire (n = 90,118) from 145 schools completed during 1994-1995 includes topics such as demographic characteristics (e.g., age, gender, and ethnicity), health-risk behaviors, extracurricular activities in the school year, and friendship nominations for the five best male and five best female friends from school rosters [28].

Sample

From the pool of adolescents completing the in-school questionnaire and the in-home interview, the Wave I in-home interview sample ($n = 20,745$) in grades 7–12 is drawn. The in-home interview includes sensitive questions including those about alcohol use and sexual behavior. Additionally, the in-home interview sample contains a subsample, called the “*saturated*” school sample ($n = 3,702$) from 16 schools where all enrolled students in the schools participated in in-home interviews. Therefore, in order to achieve our purpose, this study used the saturated sample from the two schools providing the largest samples out of the original 16, for analysis. The remaining 14 schools are excluded due to relatively small sample sizes and substantially larger amounts of missing data. Moreover, friendship nominations in these saturated schools allow us to construct complete friendship networks, indicating these networks can provide inter-relationships such as adolescent’s relations and network positions among individual adolescents.

We limited our analysis to adolescents who answered “yes” or “no” to the question, “The most recent time you had sexual intercourse, had you been drinking alcohol?” in the in-home interview, from the two schools with the largest saturated samples. This resulted in a total sample of 901 (School 1: $n = 324$ and School 2: $n = 577$) (see Figure 5).

Figure 5. Flow diagram of Sample



Measures

Friendship nominations were obtained by asking students to name up to five best male and five best female friends. The friendship nominations from the same school rosters to which the respondent belonged received unique identification codes (e.g., 12345678), whereas friends from different schools were duly identified by specific codes (e.g., 77777777). We excluded friendship nominations from different schools in subsequent analyses because these friends did not connect with each other within the same friendship networks. Using nominations from the same school rosters, we can create complete networks within a given school. These complete networks allow us to measure adolescent's relations and network positions.

We computed the following measures of friendship networks via a social network analysis computer program.

- a) Degree: defined as “the number of links to and from a person”^{p 82}. Out-degree is the number of friendship ties that the ego (person responding to the survey) nominates; in-degree is the number of friendship nominations the ego receives [16].
- b) Density: defined as the ratio of the number of actual connections divided by the total possible connections in the network [16].
- c) Betweenness (or betweenness centrality): defined as the number of times an adolescent lies on the shortest paths linking other adolescents in the network [16].
- d) Bonacich centrality: the notion that “...not only a function of how many

friends an individual has but also the number of friends one's friends have”
p²² [77].

In this study, we assessed the influence of friendship network structures upon the behaviors of sexual intercourse and alcohol consumption in tandem, based on a question in the in-home interview at Wave I. Specifically, students were asked if they had been drinking alcohol when they last had sexual intercourse. Originally, while the questionnaire offers the option of answers coded as three categorical variables (e.g., 0 = “no”, 1 = “yes”, and 3 = “refused”), we dichotomized the variable, examining only participants who answered “yes” or “no”. We also utilized gender and grade as control variables, coded as dichotomous (0 = female and 1 = male) and categorical variables (e.g., 7 = 7th grade and 8 = 8th grade) from the in-home interview at Wave I.

Statistical analyses

For descriptive analyses we employed Stata 13 (StataCorp LP, College Station, TX) as the main analytical software. Moreover, to analyze the saturated samples from the in-home interview at Wave I, we utilized the NetDraw feature in UCINET, a dynamic network analysis tool, to describe the structure of the friendship network for adolescents who engage in, and for those who do not engage in simultaneous sexual intercourse and alcohol use. Using this analytic technique, we can draw a graph to visualize the network structure of adolescents engaging in risky behaviors, and we can report network centrality degree measures (i.e., in-and out-degree).

To assess the relationship between network structure and adolescents' risk

behaviors, for each school we ran a logistic linear regression using Stata 13. In a preliminary analysis, we assessed whether students in the two schools were similar enough to agglomerate into a single sample, and found there were statistically significant differences between Schools (1 and 2) on the question regarding alcohol use during sexual intercourse ($p = 0.03$). We report our analyses, therefore, separately for each school, as students in the schools differed significantly in their responses on the surveys. Moreover, we also assessed multicollinearity, reporting variance inflation factors (VIF), among variables in the logistic regression analysis. The VIF values of all variables were below 4.42 in Schools 1 and 2, indicating multicollinearity was not a problem [78].

Results

Descriptive statistics

As shown in Table 3, we employed descriptive statistics to highlight the characteristic of the samples from School 1 ($n = 324$) and School 2 ($n = 577$), respectively. In School 1, nearly half of the students were female (49.48%), 29.1 % reported 18 years old, and 93.83% did report their ethnicity. In School 2, more than half of the students (54.1%) were male, 35.88% were 18 years old, and 91.85% did report their ethnicity.

Table 3. Descriptive statistics: gender, age, and race (n = 901)

Characteristic	School 1 (n = 324)	School 2 (n = 577)
Gender		
Male	164 (50.62%)	312 (54.1%)
Female	160 (49.48%)	265 (45.9%)
Age*		
	18.75 (1.18)	18.60 (0.96)
14	1 (0.31%)	--
15	25 (7.72%)	3 (0.52%)
16	61 (18.83%)	107 (18.54%)
17	93 (28.70%)	196 (33.97%)
18	94 (29.01%)	207 (35.88%)
19	49 (15.12%)	57 (9.88%)
20	1 (0.31%)	6 (1.04%)
21	--	1 (0.17%)
Race		
White	17 (5.25%)	15 (2.60%)
Black/African American	1 (0.31%)	13 (2.25%)
American Indian/ Native American	2 (0.62%)	2 (0.35%)
Asian/Pacific Islander	--	6 (1.04%)
Other	--	10 (1.73%)
Refused	--	1 (0.17%)
Skip and/or N/A	304 (93.83%)	530 (91.85%)

Note: * includes mean (SD)

Table 4 shows descriptive statistics for adolescents from the two schools who engage in (“yes”) and who do not engage in (“no”) drinking alcohol before having intercourse. School 1 had 50 students in the “yes” group, and 274 students in the “no” group. More than half of students in the “yes” group (62%) were boys and 34 % were 17 and 18 years old, respectively. 94% did not report their ethnicity. Among the “no” group at School 1, more than half (51.5%) of students were girls and 28.1% reported 18 years old. 93.8% were did not report their race. In School 2, 40 % were boys and 40.98% were 17 years old in the “yes” group. 85.25% did not report their ethnicity. In the “no” group, 52.7% were boys also and 37% were 18 years old. 92.6% did not report their race.

Table 4. Descriptive statistics: “yes” and “no” groups from each school

Characteristic	School 1 (n = 324)		School 2 (n = 577)	
	“yes” (n = 50)	“no” (n = 274)	“yes” (n = 61)	“no” (n = 516)
Gender				
Male	31 (62%)	133 (48.5%)	40 (65.6%)	272 (52.7%)
Female	19 (38%)	141 (51.5%)	21 (34.4%)	244 (47.3%)
Age*	18.38 (1.03)	18.82 (1.19)	18 (1.00)	18.59 (0.96)
14	--	1 (0.4%)	--	--
15	1 (2%)	24 (8.8%)	1 (1.64%)	2 (0.4%)
16	5 (10%)	56 (20.4%)	12 (19.67%)	95 (18.4%)
17	17 (34%)	76 (27.7%)	25 (40.98%)	171 (33.1%)
18	17 (34%)	77 (28.1%)	16 (26.33%)	191 (37%)
19	8 (18%)	40 (14.6%)	6 (9.84%)	51 (9.9%)
20	1 (2%)	--	1 (1.64%)	5 (1%)
21	--	--	--	1 (0.2%)
Race				
White	3 (6%)	14 (5.1%)	3 (4.92%)	12 (2.3%)
Black/African American	--	1 (0.4%)	2 (3.28%)	11 (2.1%)
American Indian/Native American	--	2 (0.7%)	1 (1.64%)	1 (0.2%)
Asian/Pacific Islander	--	--	1 (1.64%)	5 (1%)
Other	--	--	2 (3.28%)	8 (1.6%)
Refused	--	--	--	1 (0.2%)
Skip and/or N/A	47 (94%)	257 (93.8%)	52 (85.25%)	478 (92.6%)

Note: * includes mean (SD)

Networks and their characteristics

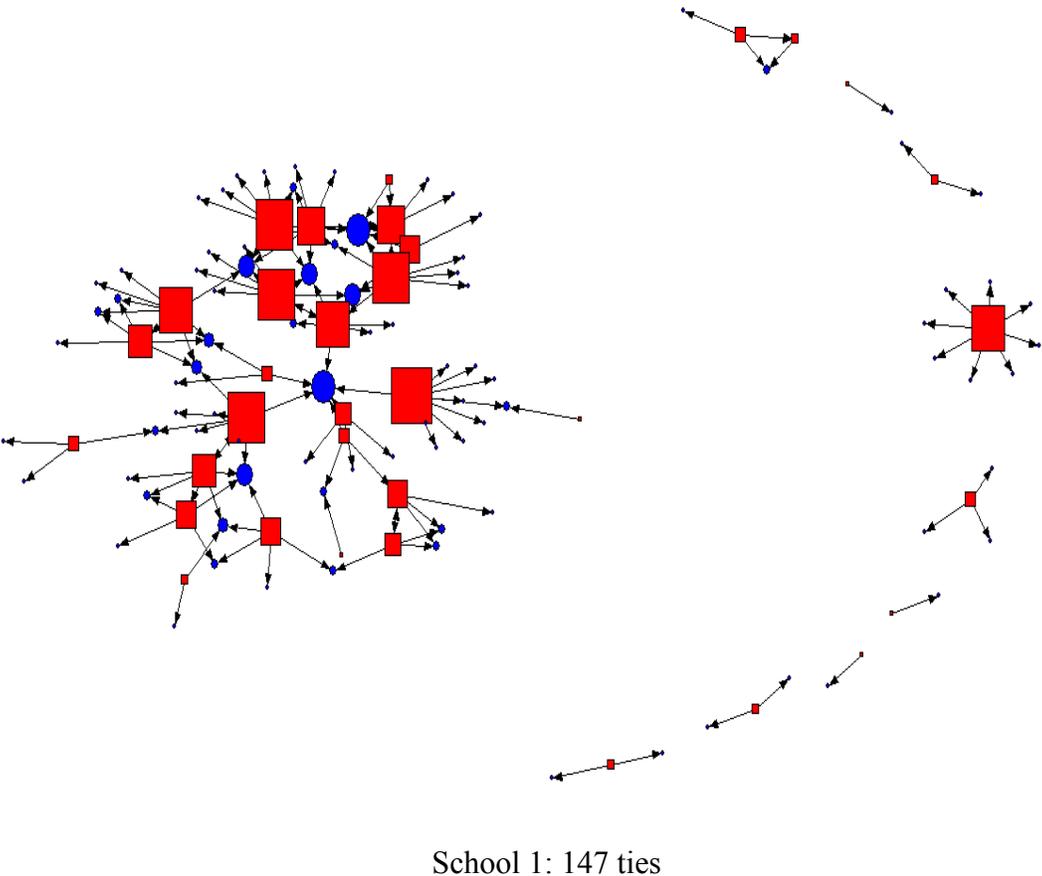
Table 5 presents descriptive network data from the two schools. In School 1, out-degree was 6.564 and density was 0.008 in the “yes” group. In the “no” group, in-degree was 4.435 and density was 0.002. In School 2, in-degree was 3.856 and density was 0.005 in the “yes” group. In the “no” group, in-degree was 2.797 and density was 0.001.

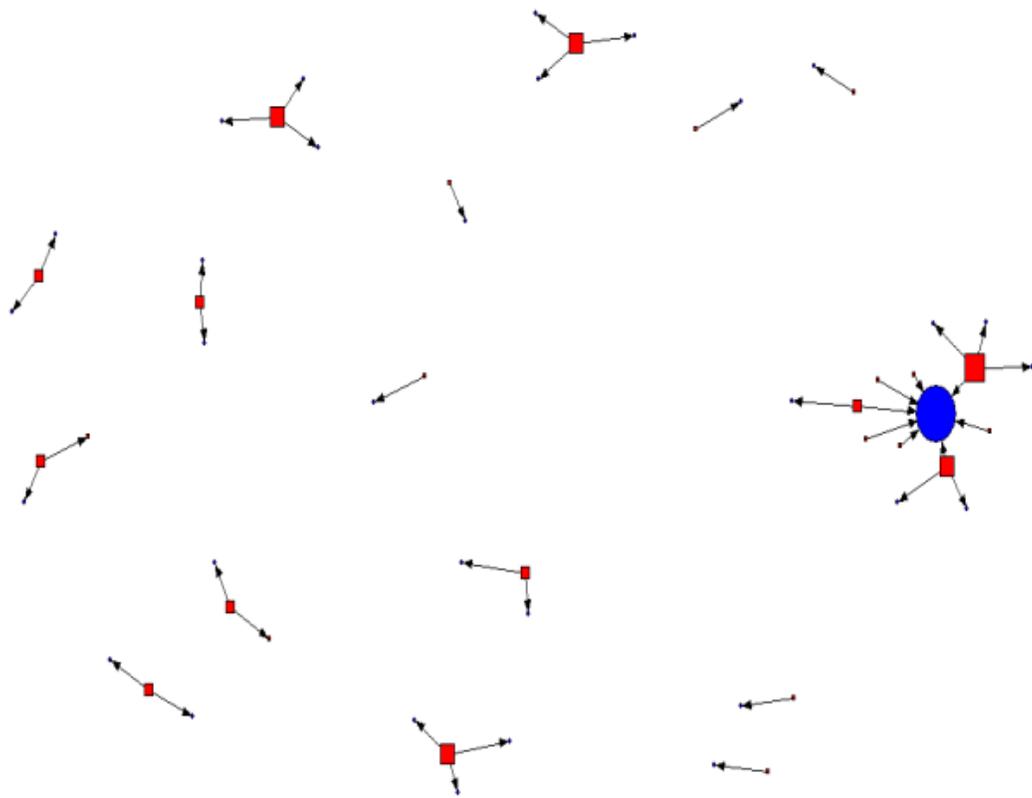
Table 5. Descriptive network characteristics from Schools 1 and 2

Network Characteristics	School 1		School 2	
	“yes”	“no”	“yes”	“no”
Degree				
In-degree	3.623	4.435	3.856	2.797
Out-degree	6.564	.940	1.292	0.333
Betweenness	0.13	0.17	0.00	0.01
Density	0.008	0.002	0.005	0.001

Figure 6 depicts the network structures of School 1 and 2 for the adolescents who *engage* in sexual intercourse and drinking alcohol. Each square (adolescents who engage in risky behaviors) or circle (their friends) represents a student in the network. Squares and circles are sized based on degree. In School 1, there are 137 adolescents with 147 ties. The graph for School 2 displays 92 students with 41 ties.

Figure 6. Network of adolescents who engage in sexual intercourse and alcohol drinking, simultaneously, within Schools 1 and 2 from the Add Health dataset

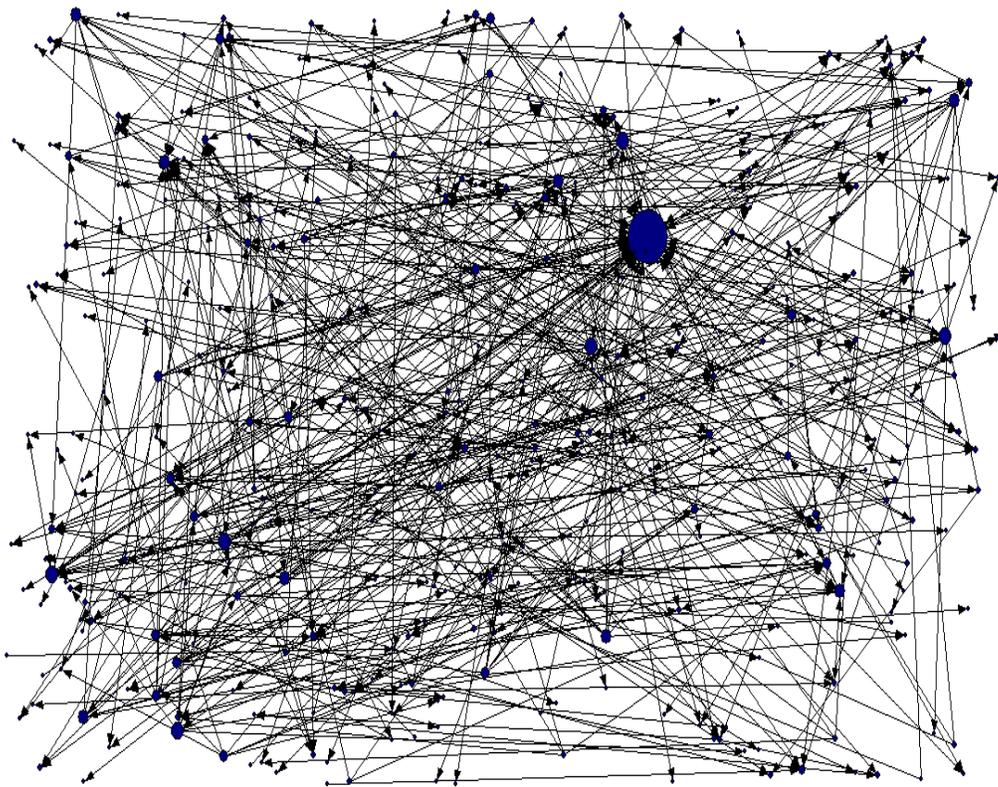




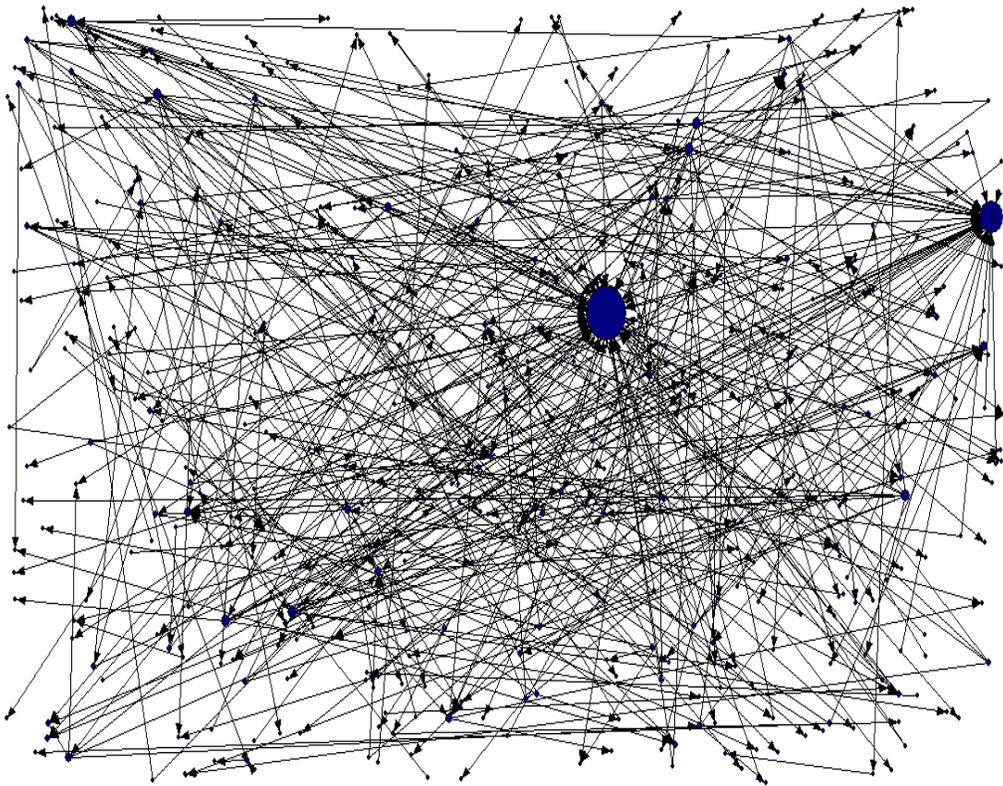
School 2: 41 ties

Figure 7 shows students (circle) who *do not engage* in the two behaviors we assessed within each school. Each circle represents a student in the network. Circles are sized based on degree. School 1 portrays 468 adolescents with 524 ties in the network. School 2 shows 701 students with 448 ties.

Figure 7. Network of adolescents who do not engage in sexual intercourse and alcohol drinking in tandem, within Schools 1 and 2 from the Add Health dataset



School 1: 524 ties



School 2: 448 ties

Assessing the influence of network structure on individual behavior

Table 6 shows the results of the probabilities (or odds ratios – OR) of engaging in sexual intercourse and drinking alcohol associated with individual-level and network-level variables for adolescents in Schools 1 (n = 324) and 2 (n = 577). The probabilities were estimated separately for each school.

In School 1, in terms of demographic predictors, age was significantly associated with simultaneous engagement in sexual intercourse and alcohol consumption (OR = .66, $p < .05$), indicating adolescents who were at a younger age were more likely to participate in these two behaviors.

We also tested network centrality measures such as degree, density, betweenness and Bonacich centrality and found out-degree and betweenness to be associated with engaging in these behaviors (sex and drinking alcohol). Engaging in sex and drinking alcohol simultaneously was significantly predicted by out-degree (students named others as a friend: OR = 1.39, $p < .05$) in this friendship network, indicating adolescents who named more friends were more likely to have an increased engagement in these behaviors. Additionally, betweenness (the fraction of the shortest path between students: OR = 1.01; $p < .05$) was significantly related with engagement in risky behaviors (sexual intercourse and drinking alcohol in tandem), indicating students who were connected through a short path with others exhibiting risky behaviors were more likely to engage in these risky behaviors, themselves.

In School 2, engagement in risky behaviors (sex and alcohol consumption simultaneously) was significantly predicted by gender (OR = .46, $p < .05$), indicating

male students were more likely to have increased involvement in risky behaviors. Moreover, as another demographic predictor, age (OR = 1.43, $p < .05$) was a significant predictor, indicating students who were older were more likely to engage in sexual intercourse and drinking alcohol at the same time. In contrast to the results from School 1, none of the network centrality measures for the School 2 sample had a statistically significant relationship with adolescents' sexual intercourse and drinking in tandem.

Table 6. Logistic regression analysis of predictors of sexual intercourse and alcohol consumption in tandem: demographic and network centrality characteristics as predictors

	School 1			School 2		
Demographic predictors	OR	SE	CI	OR	SE	CI
Gender	1.0	.45	.42–2.42	.46*	.15	.24–.88
Age	.66*	.11	.47–.94	1.43*	.24	1.04–1.98
Network predictors						
In-degree	.82	.13	.60–1.13	1.17	.76	.33–4.15
Out-degree	1.39*	.19	1.05–1.84	.74	.32	.31–1.72
Betweenness	1.01*	.00	1.00–1.02	1.21	.40	.63–2.30
Density	1.01	.01	.99–1.04	1.00	.02	.97–1.04
In-Bonacich Power	1.00	.00	.99–1.01	.83	.33	.38–1.81
Out-Bonacich Power	.99	.00	.98–1.00	.99	.02	.96–1.03

Note: Odd Ratio (OR), Standard Errors (SE), and upper and lower 95% Confidence Intervals (CI)
 * $p < .05$

Discussion

In this study, we were interested in the influence of friendship network structures upon adolescents' risky health behaviors, specifically the simultaneous behaviors of sexual intercourse and alcohol consumption. Utilizing SNA, we identified three predictors (i.e., age, out-degree, and betweenness) in School 1 and two predictors (i.e., gender and age) in School 2. These factors were significantly associated with risky behaviors (sexual intercourse and drinking alcohol in tandem) among adolescents in our sample. Our results indicated that (a) the structure of friendship relationships (i.e., out-degree and betweenness) among students was related to an increased risk for engaging in these behaviors in one school, but not in the other; and (b) demographic attributes (i.e., age and gender) also varied by school.

In School 1—as shown in Table 3 describing the characteristic of the sample—the sample size is relatively smaller ($n = 324$) than School 2 ($n = 577$), but, the friendship network in School 1 shows a larger number of connections (denser network) among adolescents sampled than School 2 (as depicted in Figure 6, School 1 had 147 ties in the “yes” group). School 2 displays a friendship network with sparser connections (also in Figure 6: School 2 had 41 ties in the “yes” group). This suggests that in this study, at least, tightly-bound friendship networks in smaller schools (School 1) may carry higher risk of engagement in sexual intercourse and alcohol consumption in tandem. On the other hand, more diffused (spread out) networks in larger schools (School 2) seem to pose less risk of engaging in these two risk behaviors simultaneously.

This finding suggests that, counterintuitively, larger networks may pose less risk, depending on how densely connected its members are.

With respect to network attributes (i.e., out-degree and betweenness) in School 1, out-degree refers to the number of friendship nominations teens made [16]. In this study, the out-degree attribute was correlated with an increased risk of engaging in sexual intercourse and alcohol consumption simultaneously. As defined earlier, out-degree refers to the nominations made by a study participant (or the number of ties that stem from a node in the directed network; in the case of friendship networks: a measure of gregariousness); in-degree refers to the nominations received by a study participant (in the case of friendship networks, a measure of popularity) [16]. In our sample, students who nominate others rather than receive nominations from others appear to influence their peers' behaviors within their friendship network. This may indicate that potentially, these students actively seek contact with other students in order to embed into friendship networks. In the study by Fujimoto and Valente, authors examined the influence of friendship types (i.e., mutual, directional, and intimate friendships) on risky behaviors (i.e., drinking alcohol and cigarette use) among adolescents. They found students who nominated others were more likely to influence their friends' smoking and drinking behaviors, than adolescents who were nominated by others [12].

Betweenness is another attribute of a network, referring to the number of times an adolescent lies on the shortest paths linking other adolescents in the network [79]. We included betweenness centrality because it can be an indirect measure of network flow or

influence spread among adolescents. Betweenness also allows us to identify individuals who would possibly exert control over others, within the network.

In this study, the betweenness attribute was significantly related with engagement in sexual intercourse and drinking alcohol in School 1. This relationship potentially indicates that individuals in the network are likely to be influenced by the risky behaviors of friends or exert influence toward risky behaviors on others, because they are connected by a greater number of geodesic paths. Additionally, it may be possible that there are individual adolescents with higher betweenness in the network, so they control or influence behavior or information flow serving as gatekeepers among the other adolescents [24]. Supporting this finding, a study conducted by Ennett et al. assessed the relationship between peer attributes and adolescents' smoking utilizing SNA. Authors found there was a significant correlation between friend's cigarette use and betweenness centrality: higher betweenness centrality was related to an increased risk for engaging in smoking behavior [11].

While these two network attributes (out-degree and betweenness centrality) were associated with risky behaviors (sex and drinking alcohol simultaneously) in School 1, no effects for network structure were found in School 2.

Consistent with previous research on adolescents' risky health behaviors and peer influence, we did find that adolescents' age was associated with an increased risk for involvement in sexual intercourse and simultaneous alcohol consumption. In School 1, adolescents who were younger were more likely to have engaged in these risky behaviors; conversely, in School 2, teens who were older were more likely to participate

in those behaviors. A study by Ali and Dwyer assessed the association between peer friendship networks and adolescent's sexual behavior. The authors documented that older adolescents enrolled in higher grades were more likely to have had sexual intercourse and multiple sexual partners [55].

Regarding gender, surprisingly, we did not find any effect in School 1. Even when we calculated a logistic regression model including only demographic variables and no network attributes, the results did not show gender as having a positive relationship with the risky behaviors (OR = .642, $p = .166$). However, in School 2, male teens were more likely to have engaged in the two risky behaviors we assessed, compared with female teens. It is possible that male adolescents within this present friendship network particularly may show high susceptibility toward risky behaviors; therefore, it led result in adaptation to practiced sexual intercourse and simultaneous alcohol consumption of their peers. It may also indicate that male teens may get an earlier start to engage in risky behaviors than females in this study. Reasons explaining why gender was a significant predictor in School 2, but not in School 1, are not clear. Findings indicated that, for School 1 study participants, knowledge about the structure of their networks superseded knowledge about individual students' gender. In other words, for School 1, if attempting to predict engagement in sexual intercourse and alcohol consumption (in tandem), having information about the network would be more valuable than information on gender. For School 2, because the network structure had no association with the behaviors, knowing the students' gender becomes valuable predictive information.

We did find in one school that adolescents' friendship network characteristics can influence their and their friends' risky behaviors, within certain contexts. These findings are in line with network theory because the theory proposes that network properties (such as network centralities: degree or density) represent mechanisms that can affect outcomes of interest [80]. Moreover, our findings suggest the underlying causes of tie formation (i.e., out-degree and betweenness) among adolescents can influence the risky behaviors of other adolescents in the network. Therefore, these findings can provide an additional layer of understanding and greater insight into the overall influence of friendship networks on adolescents' risky behaviors.

Applied to risky behaviors of adolescents (e.g., smoking or drinking alcohol), previous studies have found evidence that intrapersonal factors (e.g., attitudes or beliefs) and the relationships among adolescents (interpersonal factors) are significantly correlated with teens' risky behaviors. Such findings indicate that adolescents' risky behaviors can be influenced by friendships or observation of other teens' behaviors. Jessor's Problem Behavior Theory (PBT) helps explain this phenomenon as it proposes that problem behaviors can be explained from the perspective of three major systems acting upon each other: socio-psychological variables, such as families (i.e., parent or siblings) or friends' behaviors (perceived environment system) may affect the adolescents' beliefs or attitudes (personality system) that may predispose individual adolescents toward risky behaviors (behavior system) [76,81]. Therefore, PBT as a conceptual framework can help clarify the mechanisms through which adolescent ties can influence their behavior.

Our study makes an important contribution to the literature on adolescent health promotion because it examines engagement in two risk behaviors, simultaneously (sexual intercourse and drinking alcohol in tandem), and approaches this examination from a friendship network perspective. Nonetheless, despite its contributions, this study contains important limitations: (1) we did not include any intrapersonal variables such as attitudes, norms, or beliefs, in our analyses; and (2) we only assessed one time period (Wave I). Further analyses might include intrapersonal factors as control variables, to better tease out the potential effects of network structure(s). Also beneficial would be to examine multiple points in time (e.g., Waves I and II) in order to provide a better understanding of the changes in behavior and in network composition/structure resulting from the influence of friends who engage in risky behaviors; (3) Wave I data in the Add Health dataset were collected over 10 years ago. It is possible that our findings may not generalize to a more contemporary sample; and (4) the Add Health data set is based on self-reported data and carries with it the potential errors in recall and reporting.

Recommendations for researchers and health educators

This study suggests that denser friendships ties, coupled with specific network characteristics (i.e., out-degree and betweenness) among students in a smaller school are associated with prevalence of engagement in sexual intercourse and alcohol consumption simultaneously, as compared to a larger school. Age and gender were also found to have an association, although gender was not a factor in one of the schools.

These findings have implications for future research and for the development of health promotion programs for adolescents.

Regarding research, we believe future studies should employ SNA to examine adolescents' risky behaviors, but they should also include multi-level data (intrapersonal, interpersonal, and school characteristics) [82]. Researchers should, whenever feasible, use longitudinal data to understand the mechanisms through which friendship networks lead adolescents to change their behaviors [82].

Finally, when designing health promotion programs for adolescents, health educators should consider designing programs directed at networks of adolescents, especially dense friendship networks [83]. Given that most of these networks are school-bound, this approach only requires a shift in perspective—from an individual-centered intervention, to a network-centered one. Moreover, when designing programs to target adolescent networks, educators should attempt to learn about the composition/characteristics of the network and identify individual adolescents with high betweenness centrality—these teens may become valuable peer leaders or gatekeepers and influence many others in the network [24]. Working with these teens might be an efficient way to promote the health of the entire network.

CHAPTER IV

CONCLUSION

The purpose of this dissertation was twofold: 1) to systematically review studies of the influence of friendship networks on adolescents' risky behaviors, which utilized Social Network Analysis (SNA) and the Add Health data (a nationally representative sample) in Chapter II, and 2) to describe the structure of friendship networks for adolescents who engage in, and for those who do not engage in sexual intercourse and alcohol consumption simultaneously, as well as to assess the influence of friendship network structure upon adolescents' risky behaviors (specifically the behaviors of sexual intercourse and alcohol consumption in tandem) in Chapter III.

Taken together, findings from the studies in Chapters II and III presented in this dissertation indicated that, across the studies reviewed in Chapter II, friends engaging in risky behaviors (e.g., tobacco use, drinking alcohol, or sexual activity) in friendship networks exert influence upon other adolescents' health risk behavior. Authors of the reviewed studies acknowledge it is possible to predict adolescents who interact with friends who practice risky behaviors are at increased risk of engagement in risky behaviors, themselves. In Chapter III, we found that adolescents in denser network in smaller networks (School 1) may be at higher risk for engaging in sexual intercourse and drinking alcohol simultaneously. Moreover, we identified that network attributes (i.e., out-degree and betweenness*) in School 1 were associated with an increased risk of sexual intercourse and alcohol consumption, simultaneously. Adolescents having risky

* See definition of out-degree and betweenness centralities in Chapter III

behaviors with high out-degree may actively invite/nominate other teens to be their friends, and through this action, risky behaviors can be disseminated.

Betweenness centrality—as a network characteristic—allows us to identify adolescents who have power and control in the network. Adolescents engaging in risky behaviors with high betweenness influence their peers' behaviors within their friendship network. In addition, demographic attributes (younger age in School 1 and both older age and male adolescents in School 2) were correlated with an increased risk for the behaviors we assessed in our study (sexual intercourse and drinking alcohol in tandem).

In this study (Chapter III), we utilized network analysis as a perspective (grounded in network theory) that can account for a wide spectrum of determinants of adolescent's engagement in risky behaviors, such as socio-demographic determinants (e.g., age and gender) and friendship network structures [16,19]. Thus, our findings lead to a better understanding of how the properties of a network (e.g., centrality measures: out-degree and betweenness) may influence the behaviors of individuals forming the network. Moreover, PBT can also help explain the mechanism of influence of friendship networks on risky behaviors among adolescents, as the theory proposes that the perceived environment system (e.g., friends' behaviors) and personality system (e.g., individuals' attitude) can lead individual adolescents toward risky behaviors (behavior system) [76,84]. Therefore, in tandem, these theories/approaches can help us better understand the dynamic interplay between friendship networks and health risk behaviors of adolescents.

Findings from our study and review also can contribute to better insights for developing intervention programs. Health educators should consider designing programs directed at dense friendship networks of adolescents. Health educators also should identify individual adolescents (with high betweenness centrality) who can influence many others in the network serving as gatekeepers or peer leaders. These might be efficient and effective strategies for promoting the health of adolescents in the U.S.

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APPENDIX A

(Alphabetized list of the studies reviewed in Chapter II)

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