

The Role of Social Media Use in Adolescent Alcohol Use Accounting for Peer Alcohol Use

by

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ABSTRACT

This study aimed to advance understanding of the relation between social media and adolescent alcohol use while accounting for offline peer alcohol use, exploring offline peer alcohol use separately as a covariate and as a moderator, with an additional exploratory analysis of the relation between social media and alcohol use without offline peer alcohol use in the model. A total of 868 students (55% female) in grade 7 ($n = 468$) and grade 8 ($n = 400$) at wave 1, self-reported on alcohol use, binge drinking, and social media use as well as nominated friends from their school and grade. Data from nominated peers who also completed the questionnaires were used for peer-report of alcohol use. Data were collected annually from students at grades 8, 9, 10, and 11 were used in analyses. Final structural models consisted of a cross-lagged panel design with saved factor scores for social media and peer alcohol use predicting a categorical alcohol use variable or a binary binge drinking variable. With offline peer alcohol use as a covariate in the model, social media did not prospectively relate to subsequent grade alcohol use or binge drinking. However, without offline peer alcohol use, the path from social media use to subsequent grade alcohol use was significant but not the path to binge drinking. Offline peer alcohol use did not significantly moderate the relation between social media and subsequent grade alcohol use or binge drinking.

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INTRODUCTION

Adolescent alcohol use continues to be a public health concern in many developed countries, where alcohol is the most accessible and prevalent substance used by youth (Miech, Johnston, O'Malley, Bachman, Schulenberg, et al., 2016; World Health Organization, 2012). This trend is concerning due to the many problems associated with alcohol consumption during adolescence including poor academic performance, risky sexual behavior, and delinquency (Busch, Loyen, Lodder, Schrijvers, van Yperen et al., 2014; Miller, Butler, Richardson, Staiger, Youssef, et al., 2016; Muchimba, Haberstick, Corley, & McQueen, 2013). Given the individual and social impact of adolescent alcohol use, researchers have focused considerable attention on factors that play a role in alcohol use initiation and maintenance during this developmental period. One area of importance is peer interactions, with more recent research incorporating online peer interactions.

This study aims to explore the relation between social media and alcohol use during adolescence. I first review research demonstrating peer influence on adolescent behavior followed by specific influence on alcohol use. I then review literature on the use of social media by youth, and the role that social media might play in alcohol use. I conclude by discussing the goals and hypotheses for the current study, which make an important contribution to the literature by accounting for the influence of offline peer alcohol use in models examining the relation between social media use and adolescent alcohol use.

Peer Influence during Adolescence

With a heightened concern for social rewards, adolescents are focused on their peers' behavior. Youth continuously seek information from their peers regarding approval and prevalence of behaviors and compare this to their own conduct (Rubin, Bukowski, & Parker, 2006; Sherif & Sherif, 1964). Accordingly, adolescence is marked by an increase in peer influence on youth's decision-making, and peers are the primary context influencing social development (Erikson, 1994; Lerner & Steinberg, 2009).

In addition to an emphasis on social rewards, adolescence is distinguished by increased sensation seeking, decreased monitoring by parents, and incomplete development of cognitive

abilities (Steinberg, 2005; Windle, Spear, Fuligni, Angold, Brown, et al., 2008). These factors are linked to an increase in risk-taking and impulsive behavior. It has been suggested that the greatest disparity between social rewards / high sensation seeking and cognitive ability may occur in mid-adolescence (Cleveland, Feinberg, & Jones, 2012; Steinberg, 2004; 2005), marking this period as potentially normative for risky behavior.

Peer Influence on Alcohol Use

As the most commonly used substance among U.S. adolescents (Miech, et al., 2016), alcohol, as well as the impact of peers on beliefs and decisions regarding alcohol use, has been the subject of extensive research. Leung, Toumbourou, and Hemphill (2014) completed a systematic review of longitudinal studies between 1997 and 2011 focused on the effects of peers on adolescent alcohol use. Of the 22 studies that met inclusion criteria, all but one suggested that an association with alcohol-using peers prospectively predicted initiation of alcohol use. Some of these studies attempted to clarify the separate effects of peer selection and socialization. Socialization encompasses the process of adopting peer behaviors and beliefs, such as adolescents assimilating the alcohol beliefs of their peer group. Selection differs from socialization in that beliefs exist prior to the association with peers, and these pre-existing beliefs and behaviors lead to the creation of relationships with those who support those beliefs. For example, youth with pro-alcohol beliefs may select peers with similar beliefs; peers can then reinforce pro-alcohol beliefs as well as provide opportunities to engage in alcohol use (socialization). The review by Leung et al. (2014) concluded that significant peer socialization effects exist separate from selection effects, though the relative contribution and sequence of the two peer processes remains unclear. Other researchers have argued that socialization effects are more prominent than selection effects during early stages of alcohol use (Wills & Cleary, 1999).

Prior research suggests that socialization can occur through peer modeling, verbal communication with peers, and through media acting as a super peer. Affiliation with deviant peers, who provide the social context and model alcohol use, is one of the most robust correlates of alcohol use initiation (Dishion & Tipsord, 2011; Dodge, Dishion, & Lansford, 2007; Westling, Andrews, Hampson, & Peterson, 2008). Alongside modeling, verbal communication can impact

youth behavior; pro-alcohol discussions that occur among peers has been labeled deviancy training, and involve laughing, joking, and overall positive responses to deviant behavior. Deviancy training has been associated with not only initiation, but increases in existing substance use, including alcohol (Dishion & Tipsord, 2011; Van Ryzin & Dishion, 2014). In addition to face-to-face peer interactions, youth are socialized by “peers” in the media, which has been referred to as a super peer (Elmore, Scull, & Kupersmidt, 2017).

Alcohol Norms

Social cognitive theory suggests that the socialization process transpires through knowledge and observation of others’ behaviors and the consequences of those behaviors (Bandura, 1989). The beliefs formed through this process are labeled norms: beliefs about the prevalence and approval of alcohol use are known as alcohol norms, which can be divided further into descriptive and injunctive. Descriptive norms regarding alcohol use reflect an individual’s perception of how often and how many of their peers use alcohol, whereas injunctive norms reflect a perception regarding peer approval of alcohol use (Rimal & Real, 2005).

Researchers have found that both types of alcohol norms help explain the relation between peer alcohol use and adolescent alcohol use, such that exposure to drinking friends increases descriptive and injunctive norms, and increases in pro-alcohol norms are linked to increased alcohol use (Brechtwald & Prinstein, 2011; Brooks-Russell, Simons-Morton, Haynie, Farhat, & Wang, 2014; Janssen, Treloar Padovano, Merrill, & Jackson, 2018; Pedersen, Osilla, Miles, Tucker, Ewing et al., 2017; Trucco, Colder, & Wieczorek, 2011). Rimal and Real (2005) propose that, in conjunction to the strengthening of descriptive norms via peer modeling, descriptive norms are magnified after adolescents begin drinking and subsequently extend their own behaviors to others (i.e., false consensus effect: Henry, Kobus, & Schoeny, 2011).

It has been postulated that, like peers, media influences adolescents’ behaviors via modifications in beliefs about the behavior (Elmore, Scull, & Kupersmidt, 2017; Gunther, Bolt, Borzekowski, Liebhart, & Dillard, 2006). Media researchers have developed Cultivation Theory (see Morgan & Shanahan, 2010) and the Message Interpretation Processing (MIP) model (Austin, Pinkleton, & Fujioka, 2000), which work in tandem with social cognitive theory. Cultivation theory

posits that consistent, biased representations in the media accumulate and eventually override information from other socializing agents, such as parents, leading to changes in media users' beliefs. For example, media depictions of alcohol might associate alcohol use with high social reward, pleasant sensations, and no consequences. The MIP model proposes that media messages are the most impactful when the message is relatable to the youth's experience (similarity), appealing (desirability), and portrays the world accurately (realism). Thus, if youth observe characters/actors who are similar in demographics, enjoying themselves, consuming alcohol, and not subject to negative consequences, theory would suggest that adolescents will change their beliefs about alcohol use to align with the media depictions dependent on the similarity, desirability, and realism of the message.

The influence of face-to-face peer interactions and exposure to peers in the media can be seen in youth's perceptions of peer drinking (i.e., descriptive norms); youth consistently overestimate the amount and frequency of alcohol used by the larger peer group in middle school, high school, and college (Perkins, Meilman, Leichter, Cashin, & Presley, 1999; Perkins, Perkins, & Craig, 2018). Interestingly, adolescents also bias their estimates of close friends' alcohol use, but in the direction of their own use. For adolescents that do not drink, they underestimate their close friends' alcohol use, whereas drinking adolescents overestimate close friends' alcohol use. This phenomenon of people believing others behave as they do is known as the false consensus effect (Henry, Kobus, & Schoeny, 2011). These studies suggest that, although false consensus applies to close friendships, youth view the larger peer group as more deviant and view alcohol use as acceptable and socially normative among their extended peers.

Social Media

Many peer interactions now occur via computer-mediated communication, specifically through social media. Social media is an online platform that allows for public and private social interaction and information sharing (O'Keeffe & Clarke-Pearson, 2011). Now a universal part of adolescent communication, social media is used by 97% of youth ages 13 to 17, a drastic increase from the previous decade (Anderson & Jiang, 2018). As adolescents spend greater amounts of time with peers online, social media platforms become prime locations to gather information about

what is approved of by peers (Moreno, Parks, Zimmerman, Brito, & Christakis, 2009; Subrahmanyam & Greenfield, 2008). The rapid growth of this new domain for peer interaction incites curiosity regarding whether peer interactions online differ from traditional face-to-face interactions.

Like offline peer behavior, the information presented by peers online includes real, ideal, and exaggerated characteristics (Michikyan, Dennis, & Subrahmanyam, 2015), with few blatant falsifications (DeAndrea & Walther, 2011). Although adolescents rarely post false information, they modify their presentation in a process labeled selective self-presentation, displaying content to optimize a desired impression and removing unwanted content (Nesi & Prinstein, 2018). Even though youth engage in deliberate reputation management offline, research has shown that individuals are able to construct their online representation with more control and manage their online connections more strategically (Ellison, Heino, & Gibbs, 2006; Hancock & Dunham, 2001; Maghrabi, Oakley, & Nemati, 2014; Walther, 2007). This may be partially attributable to increased time to construct posts, edit photos, remove unwanted cues, and choose audiences for specific material.

A major motivation for tailoring profiles is a strong desire for peer approval. Through social comparison and peer feedback, youth construct their online selves in hopes of validation and acceptance (Manago, Graham, Greenfield, & Salimkhan, 2008; Valkenburg & Peter, 2011). Though striving for status is common in the offline peer domain, quantifiable markers of engagement and peer feedback are specific to online interactions. Endeavoring to gain markers of approval on social media such as 'likes', 'views', and 'followers' has been termed digital status-seeking, and there is evidence that digital status seeking during adolescence is related to later substance use (Nesi & Prinstein, 2018). Moreover, peer feedback on social media occurs rapidly, sometimes nearly instantaneously. Many learning theories suggest that immediate feedback aids in learning (Kulik & Kulik, 1988) suggesting that peer interactions on social media may be highly effective at conveying social information and approval.

In addition to the immediate feedback adolescents receive, content and feedback can come from a wide audience of peer members on social media. Although adolescents appear to

mainly use social media to communicate with existing offline friends (see Subrahmanyam & Greenfield, 2008; Valkenburg and Peter, 2007), youth's extensive online social networks are partly formed through weak social ties (Ellison, Steinfield, & Lampe, 2007; Lenhart, 2015), exemplified by items on social media such as "friends of friends." Through online networks, adolescents may interact (e.g., messaging, viewing profiles) with peers with whom they have little or no offline affiliation; this could include older youth or peers from different friend groups. Access to a wider group of peers is also possible due to minimal, if any, parental monitoring of social media as reported by adolescents (Reich, Subrahmanyam, & Espinoza, 2012). Parents may monitor with whom their children spend time in person yet be unaware of whom their children are spending time with digitally, allowing interactions with deviant peers that parents might otherwise prohibit.

Lastly, as the name would suggest, social media encompasses both social networking and the exchange of media. Media ranges from marketing and advertisements to blogs and celebrity channels to news stories, sports, and movies. Whereas media is present in youth's offline lives, it is built into social media sites as a part of the experience with peers. Newsfeeds appear on home pages with a mix of current events and friends' posts; youth can follow traditional celebrities as well as social media celebrities alongside their school friends; and advertisements appear while viewing peers' profiles (Scott, 2015; Smock, Ellison, Lampe, & Wohn, 2011). Moreover, user-generated content can become a form of media through repackaging original media content. Based on the MIP model, messages from peers should be very effective as they satisfy the similarity, realism, and attractiveness components of successful media. Youth likely view their peers as more similar to them than actors and view the messages as more realistic since they may be familiar with aspects of posts, such as places or people. Social media also allows users to manage their level of attractiveness through filters and control of their own content, increasing the desirability of messages. Advertisers have taken advantage of the effectiveness of user-delivered messages, creating interactive content (e.g., quizzes, games) and celebrity promotions on social media that encourage peer-to-peer transmission of the marketing message (Ashely & Tuten, 2015; Goh, Heng, & Lin, 2013).

Unique Effects of Social Media on Alcohol Use

Online and offline peer interactions have the potential to influence alcohol use in unique ways. With greater control of self-presentation, quantifiable peer feedback, low parental monitoring, and a wider audience of peers to observe, it is possible that social media use is a predictor of adolescent alcohol use above and beyond offline peer alcohol use.

Social media has the potential for large-scale impact relative to small groups of friends. Only a few youths need to post alcohol-content for a wide audience of peers to view, and only a few posts related to alcohol may need to be viewed to change or strengthen norms given existing misperceptions of peer alcohol use among adolescents (Perkins, Perkins, & Craig, 2018) in conjunction with the phenomenon of confirmation bias. The low rates of parental monitoring of social media may magnify the issue of easy access to pro-alcohol messages.

Moreover, the messages displayed may be more impactful than face-to-face peer interactions given the media-like quality of social media sites, with posts more effectively tailored to look exciting and attractive than possible in-person. Indeed, a study of college students found that alcohol use is often depicted as normal and free of negative consequences on social media, with profiles often omitting negative physical and emotional consequences and, instead, focusing on positive activities associated with drinking such as dancing, playing party games, or having sex (Moreno, Briner, Williams, Brockman, Walker, et al., 2010; Moreno, Briner, Williams, Walker, & Christakis, 2009). These findings suggest that social media may be similar to deviancy training, where antisocial behaviors are discussed and encouraged, creating alcohol-promoting environments. Adolescents who are exposed to a greater variety of peers through social media, some of whom engage in alcohol use and receive positive responses to posts regarding alcohol, may experience an increase in perceptions of how common and accepted alcohol use is within their age group, confirming pre-conceived notions of greater peer alcohol use than truly exists.

Conversely, it is possible that social media use constructively impacts alcohol norms. Social media allows for both public and private sharing, and researchers know very little about private use of social media. It has been posited that adolescents feel more comfortable using the internet to gain information about health topics and risky behavior (Reid & Weigle, 2014). Thus,

social media might allow for more open and in-depth communication about sensitive topics with friends, including gathering less-glamorous information such as negative consequences of alcohol use. Access to a wider group of peers and dialogue that is more open may produce youth who are more informed, especially regarding risks. Furthermore, exposure to a wide group of peers could potentially show youth that fewer of their peers use alcohol than assumed (i.e., a more accurate depiction of peer alcohol use), thereby reducing descriptive norms.

Within the environment of heightened presentation management, measurable markers of peer feedback, an expanded audience of peers, and peer-transmitted media messages, adolescents' online peer experiences may have a unique influence relative to their offline peer interactions. This potentially novel peer domain may have implications for peer socialization during adolescence, specifically socialization of alcohol use, through peer modeling, peer communication, and media portrayals via online interactions.

Moreover, the influence of social media may differ depending on stage of adolescence, with a greater impact of social media on early adolescents' alcohol use. Time with peers offline is more limited and parents have more control over their early adolescents' offline peer groups. Yet, early adolescents may be able to access social media with an extended peer group usually unavailable until later adolescent (e.g., during high school), with minimal parental monitoring. Older adolescents, on the other hand, may be exposed to offline interactions with alcohol-using peers, diminishing the impact of alcohol messages on social media.

Alcohol Content on Social Media

Although exposure to social media is ubiquitous among adolescents, exposure to specific risk behavior content on social media may vary. Alcohol use may be a risk behavior likely to be influenced by social media use given the prevalent alcohol-related content to which youth are exposed. In a sample of Belgian adolescents, Geusens and Beullens (2016) found that 97.6% of their sample had been exposed to alcohol-related content and 79.2% had been exposed several times a month or more. Interestingly, only 67.6% of these adolescents endorsed displaying alcohol-related content. Among younger U.S. adolescents, Nesi, Rothenberg, Hussong, and Jackson (2017) reported that 20.7% of students in a middle school sample had viewed alcohol-related

content and that 7.5% had posted such content. In both samples, rates of exposure were higher than rates of display, with exposure rates almost three times higher than display rates among U.S. early adolescents. These statistics emphasize the rapid and widespread dissemination of content on social media, with only a portion of youth needing to display risk behavior for a greater percentage of youth to view the content.

Researchers have also explored adolescents' interpretations of alcohol-related content on social media. For example, Moreno et al. (2009) investigated interpretations of alcohol references on Facebook through focus groups and found that adolescents interpreted alcohol references as reflections of actual use. Based on these qualitative findings, the authors suggest that viewing social media profiles with alcohol-related content might alter adolescents' descriptive norms for alcohol use.

Relation between Time Spent on Social Media and Alcohol Use

Given evidence of adolescent exposure to alcohol content, several studies have measured whether time spent on social media is related to alcohol use among youth. In a survey of students in 7th through 12th grades, adolescents reported time spent on social media, drinking days in the past year, and binge drinking in the past month. Adolescents who reported infrequent or no use of social media were less likely to have consumed alcohol and less likely to have engaged in binge drinking than adolescents who reported regular (2 hours or less a day) or heavy use (more than 2 hours a day) of social media. No differences were found between regular social media users and heavy social media users (Sampasa, Kanyinga, & Chaput, 2016). Alternatively, a study of Norwegian adolescents showed a more linear relation between social media use and alcohol use. Each one-hour increase in social media use was associated with 12% greater odds of belonging to a higher versus lower episodic heavy drinking (EHD) category, with EHD defined as 4 drinks for girls and 6 drinks for boys in a single day (Brunborg, Andreas, & Kvaavik 2017). The authors argued that more time spent on social media is a risk factor for underage problem drinking.

Although these cross-sectional studies have demonstrated a relation between time spent on social media and alcohol use in adolescence, prospective studies have provided less support for a potential causal role. For example, in a large sample of tenth grade students in California,

frequency of visits to Facebook and MySpace in the past month was not associated with alcohol use 6 months later (Huang, Soto, Fujimoto, & Valente, 2014). Similarly, findings from a sample of high school students in the Eastern U.S. showed no association between time on Facebook and alcohol use one year later (Nesi et al., 2017) when alcohol content on social media, injunctive alcohol norms, peer importance, and parental monitoring were included in the model as time 1 covariates. Time on Facebook may have been unrelated to later alcohol use due to potential mediators of the relation between the two constructs being included as covariates in the model. Indirect effects of time spent on Facebook operating through included covariates were not tested.

A limitation of both studies is the inclusion of only Facebook and MySpace, which may serve a different social purpose for adolescents than platforms such as Instagram and Twitter (Anderson & Jiang, 2018). Accounting for multiple online social networks used by adolescents, particularly social media that cater to peer-to-peer communication such as Instagram and Snapchat, may capture a different relation between social media and adolescent alcohol use.

Additionally, it is possible that direct effects of frequency of social media use on alcohol use may not be observed when potential mediators such as exposure to alcohol-related content or alcohol norms are included as covariates. More specific to viewing alcohol-related content on social media, Litt and Stock (2011) found that adolescents in an experimental condition who viewed a higher ratio of alcohol-normative profiles to alcohol-nonnormative profiles reported higher levels of alcohol-promoting cognitions compared to the control condition who viewed a greater proportion of alcohol-nonnormative profiles; alcohol-promoting cognitions included greater willingness to drink, more favorable prototypes of alcohol users, more favorable attitudes toward alcohol, greater levels of perceived alcohol use among high school students, and lower perceived vulnerability to negative consequences of alcohol. Moreover, the association between viewing alcohol-normative profiles and willingness to drink became nonsignificant with three mediators included in the model: prototype of alcohol users, attitudes toward alcohol, and descriptive alcohol norms. This suggests that norms and attitudes mediate the relation between alcohol content viewed and willingness to drink. It is possible that the relation between time spent on social media and alcohol use is a two-

step mediated process, with social media use leading to increased exposure to alcohol content, which leads to changes in alcohol norms, resulting in an increase in alcohol use.

Considering Offline Peer Alcohol Use

A major gap in the literature reviewed thus far is the absence of studies that control for offline peer group drinking when exploring the effects of social media use on adolescent alcohol use. Research is needed to explore whether peer interactions on social media have a unique relation to adolescent alcohol use, accounting for face-to-face peer interactions. Of the multiple relations among peer alcohol use, social media use, and adolescent alcohol use that may exist, three are discussed here. First, it is possible that social media use has no effect on alcohol use above and beyond peer offline drinking. Second, peer alcohol use and social media use may have separate, additive effects on youth drinking. Third, peer alcohol use and social media use may interact, with offline peer use moderating the relation between social media use and adolescent alcohol use.

The absence of a relation between social media use and adolescent alcohol use in the presence of offline peer alcohol use could suggest that social media use has no unique contribution to alcohol use above and beyond the influence of offline friends. Alternatively, this could be a result of offsetting effects of social media communications that increase and decrease risk for adolescent alcohol use, as has been demonstrated for offline peer influence (Handren, Donaldson, & Crano, 2016; Hawkins, Catalano, & Miller, 1992).

The second possibility is that peer interactions on social media have distinct effects on adolescent alcohol use when accounting for the influence of offline peer relationships. This might indicate that a different type of alcohol-related communication (e.g., more pro-alcohol) occurs on social media with existing offline friends, that social media allows communication with alcohol-using peers who are not part of an adolescent's offline life, or the impact of alcohol-related messages is greater via social media regardless of familiarity with the peers delivering the messages.

Finally, it is possible that offline peer interactions and social media use have interactive rather than additive effects. When Huang, Unger, Soto, Fujimoto, Pentz, et al. (2014) collected self-report data on friend alcohol use as part of a social media study, they found that the relation

between friends' online pictures of partying or drinking and alcohol use 6 months later was moderated by their friends' alcohol use. The influence of exposure to alcohol on social media existed only for adolescents without offline drinking friends. This finding suggests that alcohol-related content on social media influences youth in a similar manner as offline alcohol exposure, and, therefore, only has an impact, in the absence of offline alcohol exposure. Thus, having offline exposure to peer alcohol use may reduce the potential contribution of exposure to alcohol content on social media, whereas novel exposure to alcohol content via social media may be positively related to adolescent alcohol use.

Proposed Study

Research thus far on the role of social media in adolescent alcohol use has not controlled for offline peer alcohol use and has often focused on the specific social media platforms Facebook and MySpace. The goal of the current study was to explore relations between general social media use including, Twitter and Instagram, and alcohol use during adolescence while accounting for offline peer alcohol use. Peer offline alcohol use was tested as a covariate and as a moderator. These research questions were addressed using data from two cohorts over five waves (four grades) of a longitudinal study that started in middle school and continued annually through high school.

Aims/Hypotheses

1. Understand the role of social media use in the development of personal alcohol use during adolescence, while controlling for offline peer alcohol use.
 - a. I hypothesized that social media use would predict subsequent grade alcohol use above and beyond offline peer alcohol use.
2. Investigate the extent to which relations between social media use and personal alcohol use vary depending on the developmental period.
 - a. I hypothesized that social media use would be more strongly related with personal alcohol use during early adolescence compared to middle adolescence because there is less exposure to offline peer alcohol use.

3. Explore the extent to which offline peer alcohol use moderates the relation between social media use and personal alcohol use during adolescence.
 - a. I hypothesized that the relation between social media use and personal alcohol use would be stronger for youth with less offline peer alcohol exposure, and that these effects would persist across development.

METHODS

Participants

Seventh and eighth grade students, with the exclusion of those in self-contained special education classrooms, were recruited from three rural, low-income middle schools in the southeastern United States located near the University of North Carolina, Chapel Hill. Of the eligible 1,463 students, 1,205 returned parental consent forms. Approximately 75% of the consent forms returned by students indicated parental permission for their child to participate ($n = 900$), and 868 students with parental consent were present at school the day of the survey. The final sample of 868 participants comprised 468 students in grade 7 and 400 students in grade 8 at the first wave of data collection (Nesi & Prinstein, 2015; Nesi, Widman, Choukas-Bradley, & Prinstein 2017). At wave 1, the mean age of the sample was 13.12 ($SD = .78$), the gender composition was 55% female, and the racial/ethnic composition was 47.2% Caucasian, 25.7% African American, 24% Hispanic/Latino, 2.1% mixed race, and 1% Asian or Asian-American. Participant retention rates at waves 2 through 6 were 91%, 89%, 82%, 75%, and 37%, respectively. The final wave of data collection (wave 6) was particularly low as roughly half of the sample graduated from high school before the completion of the study. Relative to the number of participants who were not expected to graduate prior to wave 6 ($n = 468$), the response rate at wave 6 was roughly 69%.

Data organization and attrition. Data were analyzed by school grade instead of time of data collection. Examining the data by time of data collection would assume that students across grades have similar experiences with social media and alcohol use. This is particularly problematic in cases where a single cohort (e.g., grades 8 and 9) includes both middle school and high school students. The developmental literature notes major changes in peer relationships and risk behavior during the transition to high school, suggesting that these groups should not be combined within a single time-point. With data organized by year in school, the number of participants at each grade was as follows: 468 at grade 7, 809 at grade 8, 765 at grade 9, 728 at grade 10, 680 at grade 11, and 592 at grade 12.

Grade 7 and grade 12 data were not used in the current analysis. Grade 7 data were collected for only half of the sample and social media questions were added to the survey at the

second wave (grades 8 and 9). Grade 12 data may be biased due to dropout at the end of high school. Indeed, attrition analysis indicated that participants without data at grade 12 differed from those with data at grade 12 on number of days of alcohol use in the past year at grade 8 ($F = 4.40$, $p = .04$). Relative to participants with grade 12 data, participants without grade 12 data reported a higher mean number of days of alcohol use in the past year ($M = 1.42$, $SD = .98$ vs. $M = 1.28$, $SD = .76$) at grade 8. In contrast, attrition analyses for grades 9, 10, and 11 (relative to grade 8) found no differences in number of days of alcohol use in the past year, number of times engaged in binge drinking in the past year, time spent on Facebook, or time spent on Instagram. Comparison of variable distributions across the three initial middle schools from which participants were recruited indicated no significant group differences.

Procedure

Survey data were collected annually starting in grades 7 and 8 and continuing through grade 12. Paper consent forms were given to students to bring home to their parents and electronic consent forms were sent to parents through school email announcements. Students were given a five-dollar gift card for returning a completed consent form regardless of whether consent to participate was given, a ten-dollar gift card for completing the baseline survey, and a five-dollar gift card for completion of each annual in-school survey. Students completed an approximately one-hour computer-assisted self-interview (CASI) during the school day in the cafeteria. They were informed that the study was voluntary, could be stopped at any point without penalty, and that items could be skipped. The university's institutional review board approved study procedures.

Measures

Frequency of social media use. Data on the amount of time spent on social media were collected at waves 2, 3, 4, and 5. The question stem for frequency of use was "On a typical day, how much TIME do you spend..." followed by "on Facebook?" and "on Instagram?" at waves 2, 3, and 4, followed by "on Twitter?" at wave 4, and followed by "on Social Media in general?" at waves 3 and 4. Response options included no use, less than 1 hour, 1 hour, 2 hours, 3 hours, 4 hours, 5 or more hours. Due to different response options and the use of only one social media question at wave 5, data from this time-point were not used. The social media use survey questions aimed to

measure the same construct of frequency of use, but given the varying number of questions across waves, a latent variable was created to capture frequency of social media use for each grade. The social media latent variable included Facebook and Instagram use at grade 8, Facebook, Instagram, and general social media use at grade 9, and Facebook, Instagram, Twitter, and general social media use at grades 10 and 11.

Data missing by design included grade 8 Facebook and Instagram data for the older cohort and grade 11 Facebook and Instagram data for the younger cohort. In addition, data on twitter use was available for only grade 10 for the younger cohort and only for grade 11 for the older cohort. Finally, data for the general social media question was unavailable for grade 8 for both cohorts, grade 9 for the older cohort, and grade 11 for the younger cohort.

Alcohol use. Participants were asked about alcohol use at all six waves of data collection. Data were collected for both number of days a participant had at least one drink and number of days a participant engaged in binge drinking (5 or more drinks in a few hours). Response options for the question “In the past year, on how many days have each of the following people had at least one drink of alcohol? YOU:” included 0 days, 1-2 days, 3-5 days, 6-9 days, and 10 or more days. Response options for the question “In the past year, how often did each of the following people have 5 or more alcoholic drinks within a few hours? YOU:” included 0 times, 1-2 times, 3-5 times, 6-9 times, and 10 or more times.

Data on days participants had at least one drink in the past year was analyzed as categorical with four groups: no drinking (0 days), infrequent drinking (1 or 2 days), moderate drinking (3 to 9 days), and heavy drinking (10 or more days). Due to low endorsement of binge drinking, the resulting distribution of the variable was highly skewed. Therefore, binge drinking was dichotomized as either engaged in the past year (1) or did not engage in the past year (0).

Peer alcohol use. Peer alcohol use was measured from peer report. During the survey, sociometric procedures encouraged participants to identify close friends in their grade at their school with the question “please check the names of the people who best fit each ... close friends” followed by a list of students in their grade. Because the participants’ options for close friends were limited to their grade and school, nominated friends were eligible to take the survey. Therefore,

participants' close friends were able to complete the same questions that participants completed regarding their own alcohol use.

For nominated close friends who completed the survey, alcohol use was measured by the same two alcohol questions: number of days had at least one alcoholic drink and number of times had 5 or more alcoholic drinks in a few hours. Number of days had at least one alcoholic drink was dichotomized to (1) drank in the past year or (0) did not drink in the past year, and binge drinking was dichotomized as either (1) engaged in the past year or (0) did not engage in the past year. Based on number of friends with survey data, two percentages were calculated: percentage of friends who drank in the past year and percentage of friends who engaged in binge drinking in the past year. The percentage of friends who drank and percentage of friends who engaged in binge drinking were used as indicators of a latent variable representing peer alcohol use in past year at each grade.

Covariates.

Friends with missing survey data. To account for potential differential attrition of peers across participants in the original sample, the percentage of friends with missing survey data at each grade was included in models as a covariate.

Number of nominated friends. To account for variation in friend group size, number of nominated friends at each grade was included in the models as a covariate. Number of nominated friends was winsorized (+2 SD) at each grade due to high positive skew.

Analytic Plan

Evaluating fit. For both measurement models and structural models, model fit was evaluated within a structural equation model framework using Mplus 7.11. Fit assessments included root mean square error of approximation (RMSEA), comparative fit index (CFI), and standardized root mean squared residual (SRMR) or weighted root mean square residual (WRMR). The following cut-off scores were used to determine adequate fit: $RMSEA \leq .06$, $CFI \geq .95$, $SRMR \leq .08$ (Hu & Bentler, 1999), and $WRMR \leq 1.0$ (Yu, 2002).

Measurement models. Measurement models for frequency of social media use and peer alcohol use at all grades were tested for overall model fit. Indicators of the social media variable

included different combinations of the following variables at each wave based on available data: time spent on Facebook, on Instagram, on twitter, and on Social Media in general. Indicators of peer alcohol use included percentage of friends who drank in the past year and percentage of friends who engaged in binge drinking in the past year. Full information maximum likelihood (FIML) was used to account for data that were missing by design. To identify the models, the unit loading identification (ULI) constraint was used, fixing the loading for the direct effect on one of the latent variable indicators to equal one. The estimation method was robust maximum likelihood.

Tests of temporal configural, metric, and scalar invariance were conducted for the social media and peer alcohol use latent variables. Temporal configural invariance requires the same indicators to load on a latent variable across time (e.g., grade 8 Facebook use and grade 8 Instagram use load on the latent variable social media at grade 8 and therefore grade 9 Facebook use and grade 9 Instagram use load on the latent social media construct at grade 9), whereas temporal metric invariance involves constraining the factor loadings to be the same across time. Temporal scalar invariance includes constraining intercepts across time. Models that have temporal configural, metric, and scalar invariance can be said to measure the same construct on the same scale at different time points. Cutoff point recommendations by Chen (2007) were used to evaluate invariance. For the difference between temporal and metric invariance models, these included a change in CFI of less than .01, supplemented by a change in RMSEA of less than .015 or a change in SRMR of less than .03. For the difference between metric and scalar invariance models, cutoffs are the same for CFI and RMSEA and a change in SRMR of less than .01

Main analyses. The full structural model consisted of a cross-lagged panel design with 4 grades. Factor scores were extracted from the measurement model for use in these analyses. All models in the primary analyses included autoregressive effects to control for previous scores on respective variables, decreasing potentially confounding variance (Grimm, Ram, & Estabrook, 2017) and allowing for examination of prospective effects of predictors on changes in the outcome measures. To control for the potentially confounding effects of attrited nominated friends and differences in friend group size, percentage of friends with missing data and number of friends nominated were included as covariates at each grade. Models also included correlations between

the residuals of endogenous variables. Selection effects were accounted for by including paths from youth alcohol use to subsequent grade peer alcohol use. Selected lagged effects were included in accordance with study hypotheses related to each aim (see below). Weighted least squares means and variance adjusted (WLSMV) estimation with theta parameterization was used in the structural models to allow for inclusion of correlated residuals for categorical variables (Muthén, Muthén, & Asparouhov, 2015).

Aim 1 investigated the relation between social media use and alcohol use over time with two lagged structural equation models (one for alcohol use in the past year and one for binge drinking in the past year). Each model included social media predicting alcohol use at each subsequent grade as well as offline peer alcohol use predicting alcohol use at each subsequent grade. The models also included autoregressive effects, selection effects, and concurrent relationships previously mentioned (see figure 1). Paths from social media to subsequent grade alcohol use were constrained to be equal across grades.

Aim 2 explored whether the relation between social media use and subsequent grade alcohol use (separate models for alcohol use in the past year and binge drinking in the past year) varied by grade, accounting for offline peer alcohol use. This model differed from the model in aim 1 by freely estimating the paths from social media use to subsequent grade alcohol use. Model fit was compared to fit of the model in Aim 1 by using the DIFFTEST option in Mplus. If the unconstrained model showed improved fit relative to the constrained model, single degree of freedom tests were computed at each grade to determine the nature of the differences in relations across time.

Aim 3 examined peer alcohol use as a moderator of relations between social media use and alcohol use (separate models for alcohol use in the past year and binge drinking in the past year). This model differed from the models in aims 1 and 2 by adding the interaction term for social media use and peer alcohol use at each grade. Interaction terms were created manually using exported factor scores and predicted subsequent grade alcohol use. In addition to constraining paths from social media to subsequent grade alcohol use to be equal over time, paths from peer

alcohol use to subsequent grade alcohol use and paths from the interaction terms to subsequent grade alcohol use were also constrained to be equal over time (see figure 2).

RESULTS

Descriptive data for all study variables are presented in Table 1, and correlations among all variables are presented by gender in Table 2.

Measurement Models

Frequency of social media use. The measurement model of a latent frequency of social media use variable included two indicators at grade 8 (Facebook, Instagram), three indicators at grade 9 (Facebook, Instagram, and general social media), four indicators at grade 10 (Facebook, Instagram, Twitter, and general social media), and four indicators at grade 11 (Facebook, Instagram, Twitter, and general social media). Both the temporal configural invariance model (CFI = .992, RMSEA = .030, SRMR = .022) and temporal metric invariance model (CFI = .982, RMSEA = .040, SRMR = .035) had adequate fit to the data, and changes in fit indices between the two models (CFI = .01, RMSEA = .01, SRMR = .013) were within recommended cutoff scores by Chen (2007). The temporal scalar invariance model, however, did not fit the data well (CFI = .930, RMSEA = .070, SRMR = .085), and the changes in cutoff scores (CFI = .052, RMSEA = .030, SRMR = .050) were above recommended cutoffs.

Yoon and Kim (2014) suggested a “backward method” to exploring partial invariance, which involves releasing constraints one at a time based on the highest modification index. Based on modification indices, the parameter contributing most to model misfit was the intercept of grade 8 Facebook, followed by the intercept of grade 9 Facebook. This finding was not surprising given that frequency of Facebook use decreased over time (unlike the other social media variables which remained somewhat stable). However, removing Facebook as an indicator would likely mischaracterize social media use. Instead, the intercepts of grade 8 and grade 9 Facebook were allowed to vary. By freeing these two parameters, the partial scalar invariance model fit the data adequately (CFI = .972, RMSEA = .045, SRMR = .077) and changes in fit indices (CFI = .010, RMSEA = .005, SRMR = .042) met recommended cutoff score criteria. These analyses suggested that the same latent variable was measured at each grade but that the scales were not the same across time, specifically Facebook differed in earlier vs later grades.

Peer alcohol use. Models at each grade included two indicators: percentage of peers with survey data who drank in the past year and percentage of peers with survey data who engaged in binge drinking in the past year. Adequate model fit was found for the temporal configural invariance model (CFI = .978, RMSEA = .046, SRMR = .070), the temporal metric invariance model (CFI = .972, RMSEA = .048, SRMR = .077), and the temporal scalar invariance model (CFI = .972, RMSEA = .046, SRMR = .039). Changes in fit indices between the configural and metric models (CFI = .007, RMSEA = .002, SRMR = .007) and between the metric and scalar models (CFI = .000, RMSEA = .002, SRMR = .038) met recommended cutoff scores. These analyses suggested that the same latent variable was measured on the same scale at each grade.

Factor loadings from the measurement model that assumed full invariance and included both peer alcohol use and social media use latent variables are presented in table 3, and factor correlations are presented in table 4.

Factor scores. Full structural models with measurement models for social media use and peer alcohol use did not converge. Several adjustments were made to the model to assist with model convergence including increasing variance of the latent social media variable by designating the unit loading to .1, constraining factor loading communalities for peer alcohol use, and constraining corresponding paths across time. These adjustments were unsuccessful. Therefore, factor scores were saved for social media use and peer alcohol use and utilized in subsequent structural equation models.

Under the assumption of measurement invariance (although scalar invariance for social media use did not hold), social media use and peer alcohol use data from grades 8, 9, 10, and 11 were stacked and factor scores created from a single measurement model. Participants who were missing all data for social media use and peer alcohol use within a grade did not receive factor scores for that grade and were considered missing in subsequent structural equation models.

Main Analysis

Aim 1a: Relations between social media use and alcohol use (constrained across time). The model that included number of nominated friends and percentage of friends with data as covariates fit the data poorly (CFI = .87, RMSEA = .06, WRMR = 1.34), and the covariates were

non-significant predictors of alcohol use outcomes. The model that removed these covariates fit the data adequately (CFI = .97, RMSEA = .04, WRMR = .89). Given non-significant relations between the covariates and drinking outcomes, all subsequent models excluded the covariates.

Autoregressive paths for alcohol use, peer alcohol use, and social media use were all significant. Concurrent relations between social media use and alcohol use were all significant; concurrent relations between social media and offline peer alcohol use were significant for all except grade 9; and concurrent relations between peer alcohol use and alcohol use were significant at grade 8 and grade 9.

With respect to prospective effects, the relation between social media use and subsequent grade alcohol use was non-significant. In contrast, offline peer alcohol use consistently predicted subsequent grade alcohol use, and alcohol use consistently predicted subsequent grade offline peer alcohol use, suggesting reciprocal effects. Standardized path coefficients are presented in Figure 3.

Aim 1b: Relations between social media use and binge drinking (constrained across time). Model fit for the binge drinking model was adequate with exclusion of the non-significant covariates (CFI = .96, RMSEA = .04, WRMR = .92). Autoregressive paths for binge drinking, peer alcohol use, and social media use were all significant. Concurrent relations between social media use and binge drinking were not significant; concurrent relations between social media and offline peer alcohol use were significant for all except grade 9; and concurrent relations between peer alcohol use and alcohol use were significant at grade 8 and grade 9.

With respect to prospective effects, the relation between social media use and subsequent grade binge drinking was non-significant. Offline peer alcohol use was also not significantly related to subsequent grade binge drinking. Binge drinking at grade 9 and grade 10 predicted offline peer alcohol use at grade 10 and grade 11, respectively, providing evidence for selection effects. Standardized path coefficients are presented in Figure 4.

Aim 2a: Relations between social media use and alcohol use (allowed to vary across time). The model allowing relations between social media use and subsequent grade alcohol use to vary across time (CFI = .97, RMSEA = .04, WRMR = .88) did not fit the data significantly better

than the model with constrained paths (χ^2 difference test (2, $N = 832$) = 1.61, $p = .45$), suggesting comparable effects across time.

Aim 2b: Relations between social media use and binge drinking (allowed to vary across time). The model allowing relations between social media use and subsequent grade binge drinking to freely vary across time (CFI = .96, RMSEA = .04, WRMR = .90) did not fit the data significantly better than the model with constrained paths (χ^2 difference test (2, $N = 832$) = 1.86, $p = .39$), suggesting comparable effects across time.

Aim 3a: Peer offline alcohol use as moderator of relations between social media use and alcohol use. The moderator model fit the data poorly (CFI = .93, RMSEA = .05, WRMR = 1.23) due to inclusion of the interaction terms in the model. The path from the interaction between peer offline alcohol use and social media use to subsequent grade alcohol use was nonsignificant ($p = .47$).

In addition, the model that allowed paths from social media use, offline peer alcohol use, and the interaction term to subsequent grade alcohol use to vary across time did not statistically fit the data better (χ^2 difference test (6, $N = 832$) = 5.59, $p = .47$), suggesting comparable effects across time.

Aim 3b: Peer offline alcohol use as moderator of relations between social media use and binge drinking. Similar to the moderator model for alcohol use, the moderator model for binge drinking fit the data poorly (CFI = .91, RMSEA = .05, WRMR = 1.27). The path from the interaction between peer offline alcohol use and social media use to subsequent grade binge drinking was nonsignificant ($p = .98$).

Additionally, the model that allowed paths from social media use, offline peer alcohol use, and the interaction term to subsequent grade binge drinking to vary across time did not statistically fit the data better (χ^2 difference test (6, $N = 832$) = 6.99, $p = .32$), suggesting comparable effects across time.

Exploratory Analysis

Relations between social media use and alcohol use excluding offline peer alcohol use. To further explore the relation between social media use and subsequent grade alcohol use,

and replicate prior studies examining effects of social media use on drinking behavior, a model without offline peer alcohol was tested (CFI = .97, RMSEA = .07, WRMR = 1.10). Without offline peer alcohol use, relations between social media use and subsequent grade alcohol use were significant. Standardized path coefficients are presented in Figure 5.

Relations between social media use and binge drinking excluding offline peer alcohol use. To further explore the relation between social media use and subsequent grade binge drinking, a model without offline peer alcohol was tested (CFI = .97, RMSEA = .05, WRMR = 1.01). Without offline peer alcohol use, relations between social media use and subsequent grade binge drinking remained nonsignificant ($p = .40$).

DISCUSSION

With the rise of social media use among adolescents, new questions have emerged regarding the impact of online peer interactions on decisions about risky health behavior. Of utmost importance is understanding whether online peer interactions have a unique influence on adolescent alcohol use and binge drinking above and beyond offline peer interactions. Thus far, social media researchers have been unable to disentangle the influences of offline and online peers. In addition, research has focused mainly on Facebook and MySpace as indicators of social media use, which may not fully represent adolescent behavior across online social platforms.

This study aimed to explore the relation between social media use and adolescent alcohol use controlling for offline peer alcohol use, including less researched, yet extensively used social media platforms, Twitter and Instagram (Anderson & Jiang, 2018). Social media use was expected to predict subsequent grade alcohol use above and beyond offline peer alcohol use, possibly because of unique characteristics of social media, such as quantifiable peer feedback, greater presentation management, access to a wider peer group, and lower parental monitoring. In addition, social media use was expected to be more strongly related with personal alcohol use during early adolescence compared to middle adolescence. Lastly, offline peer alcohol use was expected to moderate the relation between social media use and personal alcohol use, such that the relation would be stronger for youth with less offline peer alcohol exposure. To explore these hypotheses, peer offline alcohol use was tested as a covariate, paths from social media to alcohol use were constrained then allowed to vary, and peer offline alcohol use was tested as a moderator. Finally, as an exploratory analysis, peer offline alcohol use was removed from the model in an effort to replicate prior studies that have not controlled for offline peer behavior.

Comparable Prospective Social Media Effects Across Time

The prospective relations between social media use and subsequent grade alcohol use as well as between social media use and subsequent grade binge drinking were relatively stable across early to middle adolescence (grade 8 to grade 11). This suggests that, when offline peer alcohol use is accounted for, the role of social media in alcohol use does not differ as youth move through adolescence or, if social media is experienced differently across adolescence in relation to

alcohol, the outcome of the experience is similar. If the experience differs but the outcome is similar, it may be that social media allows for earlier exposure to alcohol content for younger adolescents, changing alcohol norms and increasing the likelihood of alcohol use, yet younger adolescents still have limited access to alcohol. Without offline alcohol-using peers to provide alcohol, personal alcohol use may not change, despite changes in norms, potentially leaving such effects of social media undetected.

Nonsignificant Prospective Social Media Effects When Offline Peer Use Included

In models with peer alcohol use predicting subsequent grade alcohol use or binge drinking, prospective effects of social media use did not appear. When peer alcohol use was removed, however, social media use became a significant predictor of subsequent grade alcohol use, replicating prior findings in studies that did not include peer offline alcohol use (Brunborg, Andreas, & Kvaavik 2017; Sampasa, Kanyinga, & Chaput, 2016). The disappearance of social media effects when offline peer alcohol use is included might indicate that online peer interactions are extensions of offline peer interactions, an idea supported by findings that adolescents spend most of their time on social media interacting with existing offline friends (Reich, Subrahmanyam, & Espinoza, 2012; Subrahmanyam & Greenfield, 2008). Moreover, the smaller portion of youth's social media communications that involve a wider peer group does not appear to impact personal alcohol use above and beyond offline peer drinking.

Although the current study did not identify direct prospective effects of social media use on youth alcohol use, it is possible that such effects occur on a faster time scale. Measuring the impact of social media use on alcohol use a year later may give an inaccurate picture of the role of this new medium for peer interaction. Given increased impulsivity and drive for social rewards, youth may view pro-alcohol content on social media that leads to rapid changes in behavior, such as seeking to experiment with alcohol with existing friends or seeking new alcohol-using peers. Any impact of social media on alcohol use would be reflected by offline peer alcohol within a few months or possibly weeks. Moreover, the data in the current study revealed consistent concurrent relations between frequency of social media use and frequency of alcohol use. It is conceivable that this captures a prospective relation between social media use and alcohol use, appearing at the same

data collection point due to the immediacy of effects. To capture any unique prospective effects of frequency of social media use, researchers may need to measure social media use and alcohol use within months, weeks, or even days of each other.

In addition to time scale of data collection, content viewed on social media may be more important than frequency of social media use. Huang and colleagues (2014) found an association between pictures of alcohol use and youth alcohol use when controlling for offline peer alcohol use. The nonsignificant findings for social media use in the current study may be due to a weaker association between frequency of social media use and alcohol use relative to the association between alcohol content on social media and alcohol use.

Another possible explanation for the null findings is that the impact of online interactions on alcohol use are indirect. Ultimately youth must befriend alcohol-using peers to gain access to alcohol, in which case, social media use may have an indirect influence through offline peer networks. Youth who are interested in alcohol use have ample opportunity to search out like-minded others who provide access to alcohol or knowledge about where alcohol is available (e.g., parties). In this scenario, social media may strengthen selection into higher risk offline peer groups.

Similarly, social media may be indirectly related to alcohol use through reinforcement of pro-alcohol beliefs. Social media platforms can become echo-chambers of beliefs and may create an environment conducive to deviancy training, encouraging pro-alcohol norms. Indeed, prior work showed that the link between injunctive norms and intentions to drink was stronger for adolescents who were more frequently exposed to alcohol-related content on Facebook (Beullens & Vandenberg, 2016). Furthermore, most youth are actively engaged on social media, not only viewing content, but creating and participating through comments, pictures, and postings. Accordingly, active participation in content creation could increase burgeoning pro-alcohol beliefs through both reinforcement of an adolescent's own beliefs as well as positive peer feedback on the content they post. Therefore, a more inclusive model of the role of social media may include changes in alcohol norms (socialization) leading to interactions with alcohol-using peers (selection) leading to changes in personal alcohol use.

Unlike frequency of alcohol use, the relation between social media use and binge drinking in the past year remained non-significant, even when peer alcohol use was removed from the model. This may be due to low endorsement of binge drinking and subsequently diminished power to detect effects. However, it is also plausible that social media impacts frequency but not quantity of drinking. Once an adolescent enters a drinking situation, social media may have little impact on how much they drink over and above the impact of peers who are present to directly influence drinking behavior.

Nonsignificant Moderation of Offline Peer Alcohol Use

Contrary to hypotheses, offline peer alcohol use did not moderate the relation between social media use and subsequent grade alcohol use: the prospective relation between social media and alcohol use remained nonsignificant for both youth with and without offline drinking friends. One possibility is that peer alcohol use mediates the relation between social media use and adolescent alcohol use, such that social media use increases willingness to drink and access to alcohol-using peers, yet alcohol use occurs only once adolescents affiliate with a group of drinking peers. This process may occur for youth with or without drinking peers. Younger adolescents or youth with peer groups that abstain from alcohol may be exposed to positive alcohol-related content through interactions with less-familiar peers who drink, as well as opportunities to form connections with peers that have access to alcohol. Congruently, for youth already exposed to alcohol-using peers, these peers may continue to reinforce pro-alcohol beliefs through online discussion and online observation, and social media use may increase opportunities to engage in alcohol use offline by connecting alcohol using adolescents to a wider group of alcohol-using peers or providing information about where alcohol is available.

Similar to main effects, an alternate explanation for nonsignificant moderation is that content on social media is more important than frequency of social media use. Indeed, Huang and colleagues (2014) showed that alcohol content on social media was linked to alcohol use 6 months later for youth without drinking friends. This suggests that the nonsignificant findings for peer alcohol use in the current study may be due to a weaker association between frequency of social

media use and alcohol use relative to the association between alcohol content on social media and alcohol use.

Limitations

Along with many strengths of this study, including peer report of alcohol use, multiple indicators of social media use, longitudinal data, and data without differential attrition, there are also limitations. One shortcoming is the measurement of frequency of social media use, which included participants retrospective self-report of use. This method of data collection is subject to faulty recollections, and therefore possible biased social media use data, potentially leading to lower power to detect effects of social media use. Furthermore, data points were approximately one year apart, which may limit understanding of the role of social media. The high frequency of use among adolescence may lead to repetitive and therefore powerful messages that have a swift impact on behaviors that may be obscured by focusing on an extended time scale.

In addition to method and timing of data collection, information on alcohol-content viewed may have revealed a more nuanced appreciation of social media's role in alcohol use. Because social media is consumed in such high quantity among adolescents (Anderson & Jiang, 2018), the frequency of use may be a poor proxy for exposure to alcohol content. By reducing error through narrowing the variable to alcohol content viewed, a significant relation with adolescent alcohol use may be identified over and above the influence of offline peer alcohol use.

Moreover, although this study advanced prior research by including the social media platforms, Twitter and Instagram, there are many other social media outlets that could be included. For instance, in a report from the Pew Research Center, the social media platform Snapchat was the most frequently chosen (35%) as most used by youth 13 to 17 years old, with YouTube as the next most frequently used (32%) (Anderson & Jiang, 2018). Snapchat, in particular, may be influential for substance use given the temporary nature of the messages, which disappear after the recipient views the message, possibly conveying a sense of privacy when discussing deviant behavior.

Restricted availability of peer report of alcohol use is another limitation. Though including direct peer report is an improvement from participant reports of peer alcohol use, data in the current

study were limited to peers from the same school and grade who participated in the survey. Because of this, valuable information regarding alcohol use within participants' wider peer group (i.e. older or younger school friends, work friends, neighborhood friends) was unavailable for analysis. Even with this exclusion, however, prospective effects of peer alcohol use were consistently demonstrated across time. In addition, information was unavailable for the participants who declined to take part in the study. Therefore, it was not possible to compare those who did and did not participate in order to explore biases in the study sample.

Finally, only partial measurement invariance was established for social media use. Scalar non-invariance was found for social media use due to the intercepts of Facebook at grade 8 and grade 9. This finding was not surprising given that frequency of Facebook use decreased over time while other social media variables remained somewhat stable. Facebook remained in the model and invariance was assumed because removal of Facebook as an indicator would likely mischaracterize social media use. Although non-invariance may be problematic, Putnick and Bornstein (2016) suggest that rejecting non-invariant models is premature because substantial research on real-life implications of non-invariance has not accumulated; instead, researchers should interpret non-invariance in the context of the construct. We believe Facebook is an important indicator for social media use, given that more than half of youth ages 13 to 17 endorse using this platform (Anderson & Jiang, 2018). Therefore, we did not remove Facebook from the model. Another option would be to use a partially invariant model by freeing the intercepts for Facebook to differ across time. However, Guenole and Brown (2014) found that ignoring a non-invariant intercept (or factor loading) did not produce significant bias in parameter estimates. Given that metric invariance was established, we proceeded with analyses assuming measurement invariance for social media use.

Future Directions

Whereas the field of peer influence on health behavior is well-established, the addition of peer influence via online interactions is new, and there are many research questions to be explored. A fruitful next step would be to explore alternate ways to measure and collect data on social media use. Ecological momentary assessments (EMA) could be used to collect real-time data about

social media use, minimizing recall bias as well as allowing the study of microprocesses that may influence youth alcohol use. EMA may involve brief self-report questionnaires about current or recent (i.e., minutes or hours) behavior (Orben & Przybylski, 2019), along with phone technology that tracks frequency of use of social media phone applications. Mobile phones might also be used to capture screenshots of social media use, followed by using computer programs to code and index the images for alcohol use.

In addition to quickening the time scale of data collection, these newer data collection methods would allow information on content viewed on social media to be gathered more reliably than participants' self-report of content viewed. Researchers might then more effectively explore questions about frequency of exposure to alcohol content and the relation between exposure to alcohol content and alcohol use. Based on the current findings, as newer research methods advance, it will be important to continue accounting for peer drinking when investigating exposure to alcohol use content on social media and adolescent alcohol use.

Moving forward, a more nuanced approach to social media platforms would be appropriate. Given differences in frequency of use between platforms such as Facebook and Twitter, examining differences in social function may benefit the field. Whereas Facebook may be used to communicate with family and the content of posts may be unobjectionable, Twitter and Snapchat may be used to interact with peers and include risky health behavior messages. Moreover, popularity of social media can fluctuate rapidly; according to Madden, Lenhart, Cortesi, Gasser, Duggan, et al. (2013), MySpace accounts among adolescents decreased from 85% in 2006 to 7% in 2012, exemplifying how quickly changes occur in the world of social media. There are also less-researched social platforms such as chat rooms, blogs, multiplayer online games, and massively multiplayer online role-playing games, to be included in future work.

Part of the importance of diversifying and distinguishing between social media platforms is that users may differ across platforms. Huang, et al. (2014) found that demographic information differed across social media platforms: compared to MySpace users, participants who only had a Facebook account had higher grades, higher SES, spoke more English at home, and were less likely to have smoked or consumed alcohol. This suggests that other participant characteristics

such as sensation seeking, impulsivity, SES, depression, parent education, and parent drinking, and other known risk factors for adolescent alcohol use, could differ by type of social media used. Along the same lines, there is research to suggest that social media may serve different social purposes for males and females (Manago et al., 2008; Nesi, & Prinstein, 2015). Madden and colleagues (2013) reported that males and females differed in several areas of social media use such as content posted, privacy settings, and social media platform preferences. The differences in online social media activity implies possible differences in the impact of social media use, though no consistent pattern of gender differences in relations between social media use and alcohol use were apparent in the current study (See table 2).

In addition to differences in social function and user characteristics, it may be important to better understand characteristics of social media peer groups and audiences as well as distinguish between public and private communication on social media. Private communication may differentially relate to risky health behaviors. Adolescents may be more likely to ask questions or share information about substance use and risky health behaviors through more private avenues, possibly because private sharing may be more difficult to monitor by parents. Relatedly, the impact of content may depend on with which 'friends' youth communicate. Within social media networks, there is undoubtedly varying degrees of intimacy, and postings from less well-known peers may impact youth differently than postings from close friends. High status youth may have a greater influence as well, stemming from adolescents' desire for popularity (Sandstrom, 2011) and the belief that imitating popular peers will help them achieve greater social status (Teunissen, Spijkerman, Prinstein, Cohen, Engels et al., 2012). Social media relationships with older peers may also have a stronger relation to alcohol use than social media relationships with same age peers. Because they are further along in development, alcohol use will be more normative and exposure to drugs more prevalent among older adolescents (Brown, McGue, Maggs, Schulenberg, Hingson, et al., 2009) allowing adolescents access to viewing alcohol at an earlier age.

Further, possible protective factors should receive more attention. For example. Moreno and colleagues (2009) found that MySpace profiles with high religious content were less likely to have risk behavior content, which parallels the offline protective influence of religion (Wallace,

Brown, Bachman, & Laveist, 2003). Additionally, parental monitoring of social media may be protective. Although the importance of offline parental monitoring is well known (Ryan, Jorm, & Lubman, 2010), levels of parental monitoring of social media use are extremely low (Reich et al. 2012) and their relation to risky behavior is largely unknown.

Although more complex research designs are needed to account for user characteristics, separate social media platforms, privacy settings, types of peer interactions, alcohol content viewed, recall bias, and protective factors, such studies may still reveal a nonsignificant relation between social media and alcohol use when offline peer alcohol use is included. Social media may have no causal role and may instead merely reflect offline peer behavior in relation to adolescent alcohol use. On the other hand, it may be that social media has no direct effect on adolescent alcohol use, and instead impacts alcohol use through alcohol norms. Future research efforts may be better expended on exploring alcohol norms as an outcome as well as narrowing the focus from frequency of social media use to frequency of exposure to alcohol-related content on social media. Based on the current findings, researchers should continue to include peer alcohol use as a covariate in models exploring the impact of social media. Moreover, given the presence of social media effects when peer alcohol use is not included in the model, it may be fruitful to explore peer alcohol use as a mediator of the relation between frequency of social media use, or alcohol-content viewed on social media, and adolescent alcohol use.

Summary

Despite the limitations, the current study yields important findings. Unlike prior work, this study was able to examine the relation between social media use and adolescent alcohol use while controlling for offline peer alcohol use. Analyses showed that the relation between social media use and subsequent grade alcohol use was consistent across early and middle adolescence when accounting for offline peer alcohol use. Additionally, this examination uncovered that time on social media did not predict subsequent grade alcohol use or binge drinking above and beyond offline peer alcohol use, but a prospective relation between social media use and alcohol use existed when offline peer alcohol use was not included in the analyses. This information is valuable given recent research that suggests social media use may be harmful for youth in regard to alcohol use

(Brunborg, Andreas, & Kvaavik 2017; Geusens & Beullens, 2016; Nesi et al. 2017; Pegg, O'Donnell, Lala, & Barber, 2017; Sampasa, Kanyinga, & Chaput, 2016). These recent studies, however, were unable to control for offline peer alcohol use, making findings difficult to interpret accurately as the relation found between social media and alcohol use may be capturing the relation between offline peer use and youth alcohol use. Lastly, offline peer alcohol use did not moderate the relation between social media use and alcohol use across early and middle adolescence. Future studies replicating these findings will be important in understanding the role of social media use in adolescent alcohol use. Replication would imply that frequency of social media use does not have a unique impact on adolescent alcohol use or binge drinking beyond offline peer alcohol use nor does peer alcohol use moderate the relation between social media use and adolescent alcohol use.

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Table 1

Distribution of study variables

Social Media	Grade 8 (N = 809)			Grade 9 (N = 765)			Grade 10 (N = 728)			Grade 11 (N = 680)						
	n	M	SD	n	M	SD	n	M	SD	n	M	SD				
Facebook use	343	2.10	2.12	748	1.68	1.98	723	1.29	1.68	322	1.26	1.60				
Instagram use	342	2.23	2.32	747	1.95	2.06	723	2.21	2.02	322	2.28	2.01				
Twitter use							369	1.72	2.07	322	1.68	1.96				
General Social Media use				389	3.29	2.27	722	3.45	2.21	320	3.58	2.08				
Peer Alcohol																
% friends with data who endorsed alcohol use	782	20%	0.20	721	31%	0.28	644	40%	0.31	589	48%	0.36				
% friends with data who endorsed binge drinking	782	8%	0.13	721	13%	0.20	644	21%	0.27	589	28%	0.33				
Covariates																
Number of nominated friends	807	13.9	13.76	756	11.66	12.04	718	10.14	9.85	678	8.02	7.83				
Average % of nominated friends with data	807	62%	0.21	756	55%	0.23	718	43%	0.22	678	42%	0.23				
Alcohol use frequency	0	1-2	3-9	10+	0	1-2	3-9	10+	0	1-2	3-9	10+				
Alcohol use	82%	11%	4%	3%	70%	16%	9%	5%	63%	17%	14%	7%	56%	17%	14%	13%
Binge Alcohol use	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes				
	93%	7%	88%	12%	81%	19%	76%	24%								

Table 2.

Correlations of study variables by gender, females in the lower triangle.

	Alc 8	Alc 9	Alc 10	Alc 11	Binge 8	Binge 9	Binge 10	Binge 11	SM 8	SM 9	SM 10	SM 11	PA 8	PA 9	PA 10	PA 11	Fri Ct 8	Fri Ct 9	Fri Ct 10	Fri Ct 11	% Dat 8	% Dat 9	% Dat 10	% Dat 11
Alcohol Use G8	.46	.29	.25	.56	.45	.35	.34	.06	.05	.07	.02	.15	.02	.18	-.01	.04	-.03	.10	-.01	.07	.07	.07	.07	-.01
Alcohol Use G9	.41	.57	.43	.45	.64	.58	.49	.07	.06	.03	-.02	.10	.23	.25	-.09	.02	-.03	.04	.02	.07	.06	.06	.04	.04
Alcohol Use G10	.40	.53	.64	.30	.42	.70	.58	.05	.09	.13	.16	.13	.25	.30	.00	.17	-.01	.02	-.04	.10	.05	.08	.05	.08
Alcohol Use G11	.25	.36	.54	.19	.25	.58	.73	.16	.05	.18	.21	.12	.21	.27	-.08	.07	-.04	.01	.00	.16	.07	.14	.07	.14
Binge Drinking G8	.56	.17	.14	.07	.57	.32	.21	.02	-.02	.04	.06	.08	.11	.18	-.03	.04	-.03	.00	-.02	-.05	.04	-.05	.04	-.11
Binge Drinking G9	.32	.56	.37	.25	.27	.58	.29	.05	.10	.05	.00	.12	.17	.14	.01	.09	-.01	-.01	-.01	-.00	.03	-.03	.03	-.04
Binge Drinking G10	.29	.32	.61	.41	.26	.36	.52	.11	.10	.09	.13	.06	.19	.20	-.06	.18	-.03	.02	-.02	.08	.04	.04	.03	.03
Binge Drinking G11	.21	.34	.47	.58	.14	.35	.50	.07	.07	.11	.21	.13	.12	.14	-.03	.04	.06	.09	-.01	.13	.01	.07	.12	.13
Social Media G8	-.02	.03	.03	.05	.00	.01	-.07	.01	-.07	.28	.28	-.01	.10	.12	-.02	.06	-.01	.04	-.06	.01	-.01	-.01	.09	.02
Social Media G9	.06	.11	.14	.16	-.05	.06	.02	.13	.28	.44	.33	.03	.03	.04	.14	.19	.09	.13	.08	.01	.07	.12	.12	.13
Social Media G10	.08	.11	.12	.13	.00	.07	.03	.07	.37	.53	.42	.04	.03	-.03	.05	.14	-.13	.06	.00	.04	.12	.17	.12	.12
Social Media G11	.02	-.06	-.04	.09	.03	.03	-.05	.07	-.02	.30	.40	.08	.03	.07	.20	.13	.04	.06	-.03	.05	.01	-.04	.04	.08
Peer Alcohol G8	.12	.16	.12	.06	.09	.13	.08	.08	.03	.06	.10	.08	.16	.15	.07	.00	.00	-.03	.05	-.19	.07	.09	.02	.02
Peer Alcohol G9	.14	.25	.17	.13	.06	.18	.14	.09	-.01	.03	.03	.02	.16	.21	.25	-.07	-.01	-.09	-.02	.03	.03	.02	.01	.01
Peer Alcohol G10	.08	.16	.20	.22	-.02	.18	.13	.15	.06	.17	.13	.11	.19	.19	.25	-.01	.01	.02	.02	-.00	.06	.09	.01	.01
Peer Alcohol G11	.05	.10	.12	.11	.08	.15	.12	.09	.11	.18	.17	.11	.03	.21	.08	.05	.08	.07	.06	.12	.06	-.02	.10	.10
Friend Count G8	.00	-.02	.08	.14	-.06	.01	.09	.06	.10	.14	.11	.16	-.06	.05	.01	.25	.25	.55	.28	.35	-.03	.11	.09	.09
Friend Count G9	-.02	-.02	-.01	.07	-.04	-.08	-.02	-.01	.03	.07	.01	.18	-.02	.00	.47	.07	.39	-.03	.36	.05	.05	.09	.09	.09
Friend Count G10	-.09	-.02	.04	.05	-.02	-.01	.03	.02	.11	.11	.02	.10	-.02	.00	.31	.29	.40	.36	.17	-.10	.21	.14	.14	.14
Friend Count G11	.01	.00	.03	.08	.01	.02	.01	.08	-.06	-.05	-.01	.11	.04	.01	.26	.44	.40	.31	.01	.15	.08	.27	.27	.27
% Friends with data G8	.04	.04	.07	.05	.02	.01	.02	.08	.06	.05	.01	-.13	-.02	-.02	-.02	.26	.26	-.05	.08	-.01	.10	.09	.18	.18
% Friends with data G9	.05	.03	-.04	.02	.05	.01	-.03	.01	-.08	-.02	-.02	.05	.04	-.03	-.03	-.03	-.09	.21	.10	-.18	.30	.25	.25	.25
% Friends with data G10	-.06	-.11	-.06	-.05	-.03	-.07	-.03	.08	-.02	-.02	.01	-.10	-.09	-.02	-.04	.02	.00	.31	.09	.19	.23	.35	.35	.35
% Friends with data G11	.00	.02	.02	.06	-.01	-.05	.02	.00	.02	.01	.02	.03	-.05	-.01	-.03	.09	.06	.15	.23	.14	.20	.36	.36	.36

Bolded numbers are significant at $p < .05$

Boxed numbers indicate correlation was significant for one gender

Table 3

Standardized Factor Loadings on Peer Alcohol Use Latent Construct with Two Indicators and Social Media Use Latent Construct with Two to Four Indicators from Combined Measurement Model

	Grade 8	Grade 9	Grade 10	Grade 11
Instagram	1.02 (.06)	.93 (.03)	.90 (.02)	.83 (.03)
Facebook	.45 (.04)	.39 (.03)	.42 (.03)	.38 (.03)
General social media		.73 (.03)	.70 (.02)	.67 (.03)
Twitter			.78 (.03)	.76 (.03)
	Grade 8	Grade 9	Grade 10	Grade 11
Peer Alcohol	.63 (.04)	.70 (.04)	.75 (.04)	.82 (.04)
Peer Binge	.81 (.04)	.79 (.04)	.72 (.04)	.76 (.04)

Table 4

Correlations between latent factors of peer alcohol use and social media use estimated by model

	G8 PA	G9 PA	G10 PA	G11 PA	G8 SM	G9 SM	G10 SM
Grade 8 PA							
Grade 9 PA	.22 (.07)						
Grade 10 PA	.13 (.07)	.43 (.06)					
Grade 11 PA	.15 (.07)	.30 (.07)	.59 (.06)				
Grade 8 SM	.10 (.08)	.06 (.05)	.08 (.06)	.11 (.05)			
Grade 9 SM	.07 (.05)	.02 (.05)	.16 (.04)	.16 (.05)	.53 (.06)		
Grade 10 SM	.12 (.05)	.02 (.05)	.09 (.05)	.18 (.07)	.66 (.07)	.61 (.05)	
Grade 11 SM	.03 (.07)	.04 (.07)	.14 (.06)	.15 (.07)	-	.53 (.06)	.61 (.05)

Note. PA = peer alcohol use, SM = social media use

Bolded numbers are significant at $p < .05$

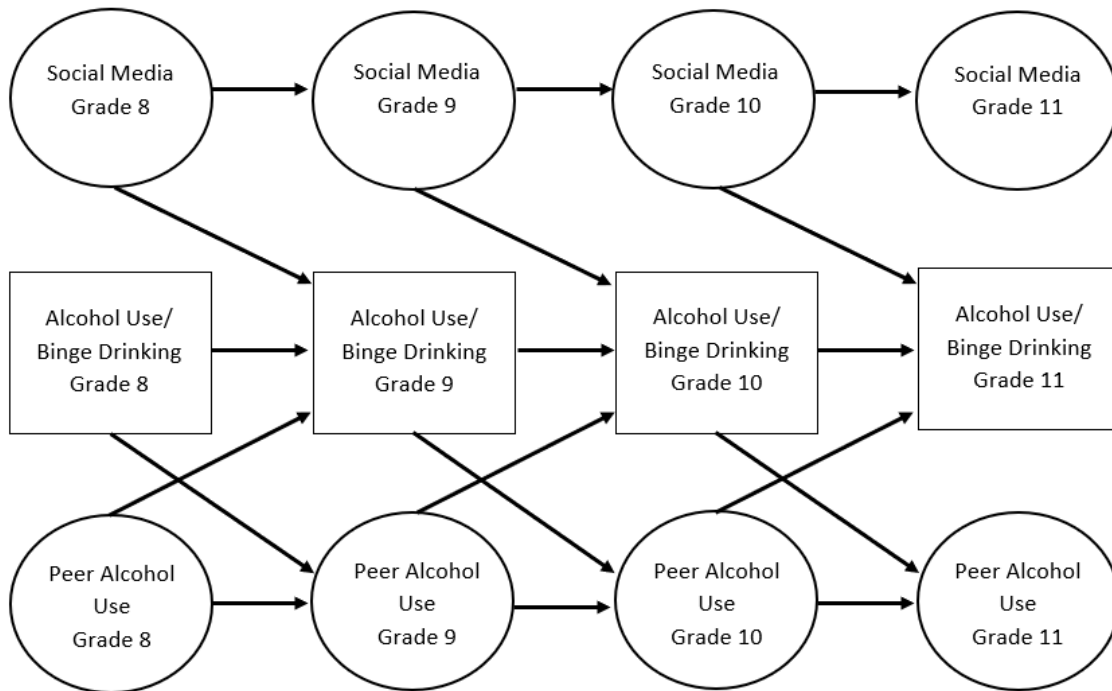


Figure 1. Lagged model with peer alcohol use and social media use predicting subsequent grade a) alcohol use in the past year b) engaging in binge drinking in the past year. Correlations among endogenous variables and covariates capturing percentage of friends with data at each grade and number of nominated friends at each grade are not shown.

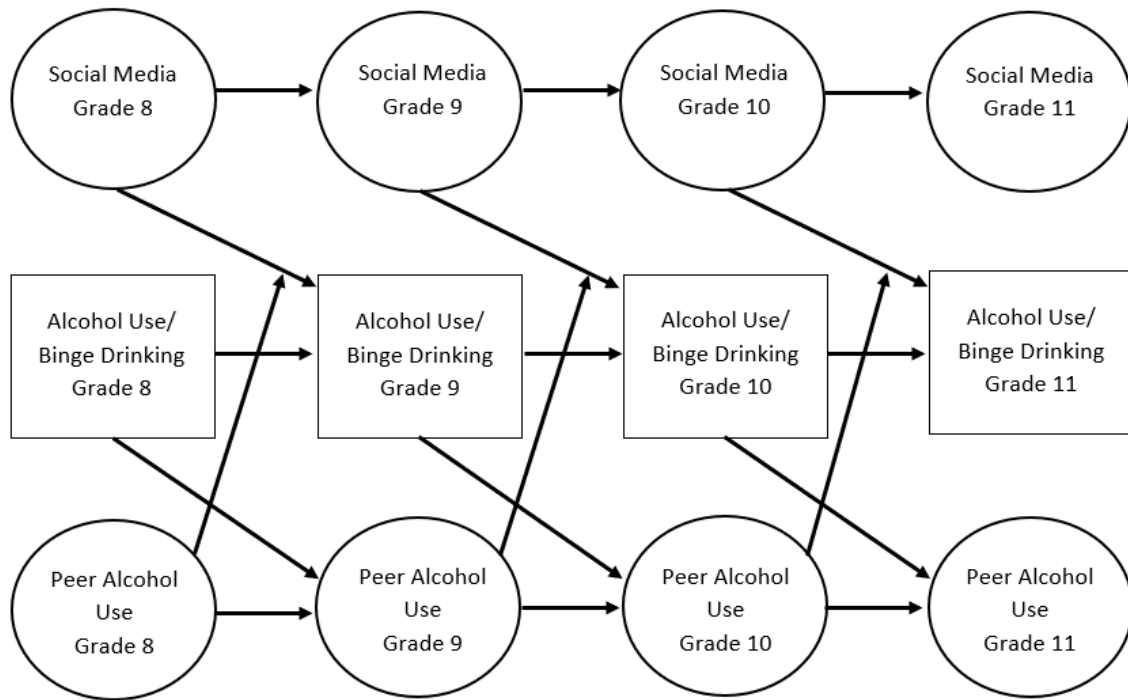


Figure 2. Lagged model with social media use predicting subsequent grade a) alcohol use in the past year b) engagement in binge drinking in the past year with peer alcohol use moderating the path between social media use and alcohol. Correlations among endogenous variables and covariates capturing percentage of friends with data at each grade and number of nominated friends at each grade are not shown.

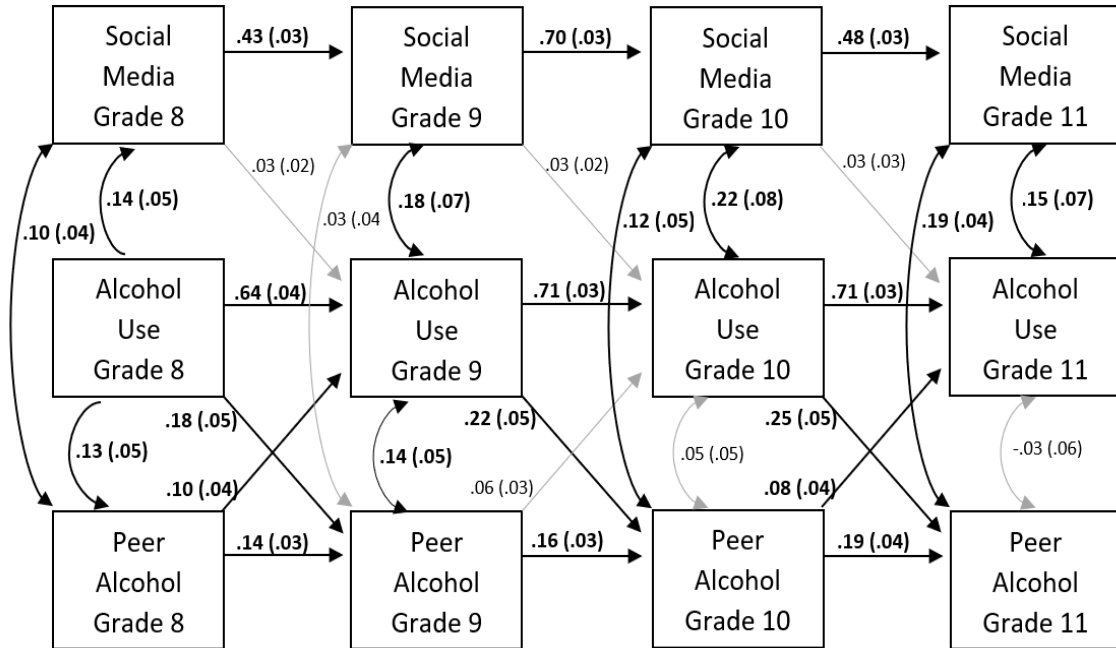


Figure 3. Lagged model with peer alcohol use and social media use, as factor scores, predicting subsequent grade alcohol use in the past year. Peer selection effects and concurrent relations (e.g., correlations) included. Gray lines indicate nonsignificant paths. Black lines with bolded parameters are significant.

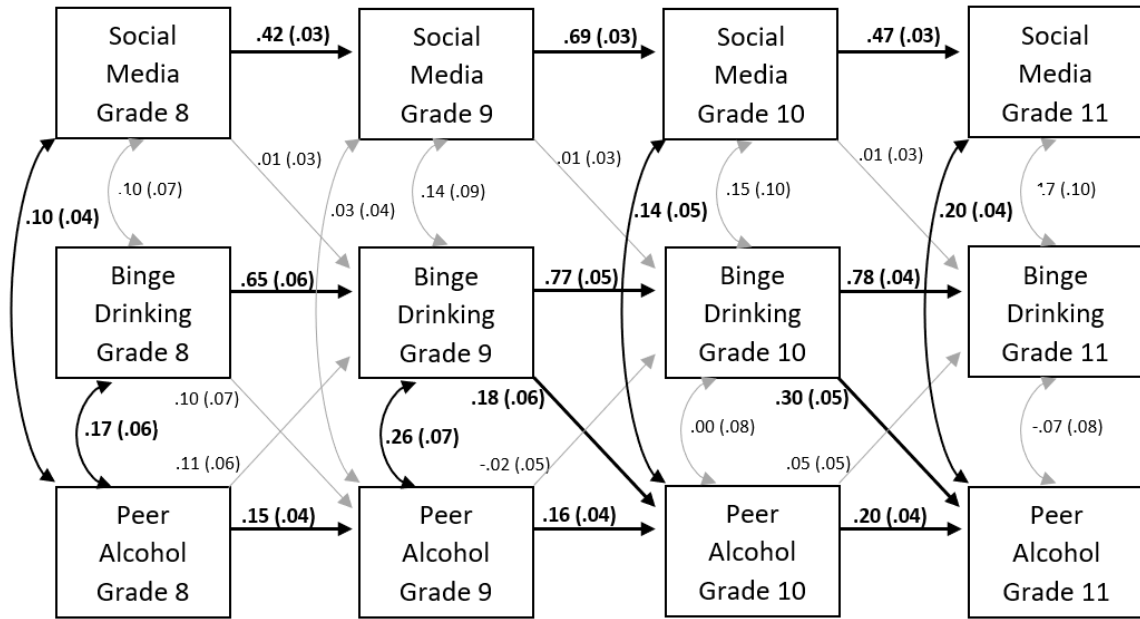


Figure 4. Lagged model with peer alcohol use and social media use predicting subsequent grade binge drinking in the past year. Peer selection effects and concurrent relations (e.g., correlations) included. Gray lines indicate nonsignificant paths. Black lines with bolded parameters are significant.

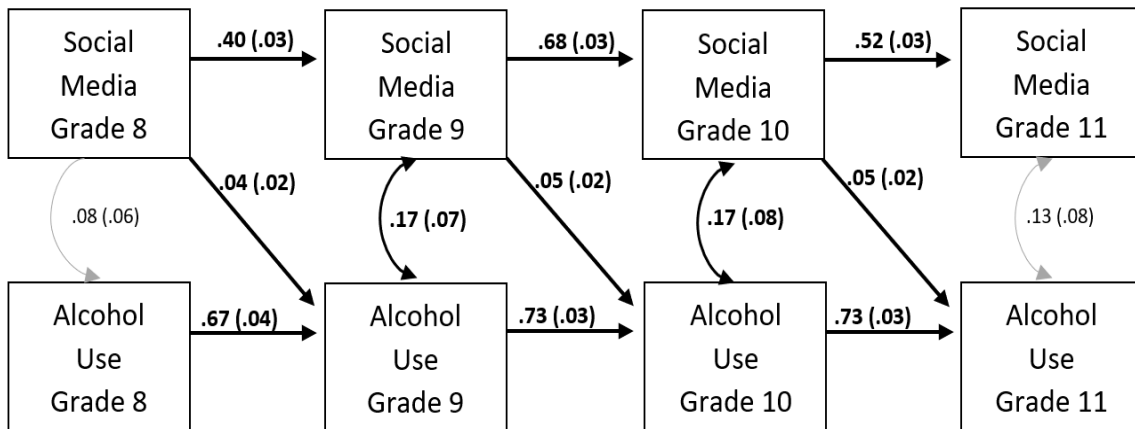


Figure 5. Lagged model with social media use predicting subsequent grade alcohol use in the past year excluding offline peer alcohol use. Concurrent relations (e.g., correlations) included. Gray lines indicate nonsignificant paths. Black lines with bolded parameters are significant.