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# Substance Use Homophily Among Geosocial Networking Application Using Gay, Bisexual and Other Men Who Have Sex With Men

**Ian W. Holloway, MSW, MPH, PhD**[1]

[1]Depatment of Social Welfare, Luskin School of Public Affairs, University of California, Los Angeles, Los Angeles, CA

## Abstract

Geosocial networking applications (GSN apps) represent important virtual contexts in which gay, bisexual and other men who have sex with men (MSM) seek affiliation. These apps allow users to create and view public profiles, send photos and text messages, and connect with other users based on shared interests and geographic proximity. The present study examined substance use homophily among a sample of of 295 MSM recruited via a popular GSN app. Comparisons of social network members met via GSN app versus elsewhere and associations between both individual and network characteristics and recent binge drinking, marijuana use and illicit substance use were explored using bivariate tests of association and multivariate logistic regression analyses. High rates of recent binge drinking (59 %), marijuana use (37 %) and illicit substance use (27 %) were observed among participants. GSN app use greater than one year and showing naked chest or abs in a profile picture were positively associated with recent illicit substance use. In multivariate analyses, the strongest predictors of binge drinking (AOR = 3.81; 95 % CI = 1.86–7.80), marijuana use (AOR = 4.12; 95 % CI = 2.22–7.64) and illicit substance use (AOR = 6.45; 95 % CI = 3.26–12.79) were the presence of a social network member who also engaged in these behaviors. Social network interventions that target binge drinking, marijuana use and illicit substance use may be delivered via GSN apps to reduce the prevalence of substance use and related risks among MSM in these virtual contexts.

### Keywords

MSM; networks; technology; binge drinking; substance use

## Introduction

Substance use and misuse is a major public health problem among gay, bisexual and other men who have sex with men (hereafter MSM). Alcohol and recreational drug use are highly prevalent in this population (Cochran, Ackerman, Mays, & Ross, 2004; Stall et al., 2001) and have been associated with other health issues including sexual risk behaviors (Celentano

Corresponding Author: Ian W. Holloway, MSW, MPH, PhD, Department of Social Welfare, Luskin School of Public Affairs, University of California, Los Angeles, 3250 Public Affairs Building, Box 951656, Los Angeles, CA 90095-1656, Phone: 310-825-7840, Fax: 310-206-7564, holloway@luskin.ucla.edu.

et al., 2006; Greenwood et al., 2001; Hirschfield, Remien, Humberstone, Walavalkar, & Chiasson, 2004; Operario et al., 2006). Attempts to explain the association between substance use and sexual risk include alcohol- or drug-induced disinhibition (Colfax et al., 2004; Drumright et al., 2006; Semple, Patterson, & Grant, 2002), erotic arousal (Schilder, Lampinen, Miller, & Hogg, 2005), and increased length of sexual sessions leading to greater opportunities for engagement in risk behaviors (Guss, 2000). However, the ways in which MSM meet substance use and sexual partners and the contexts in which substances are used remain underexplored. Understanding the contexts of MSM's substance use (i.e., where and with whom substances are used) may inform the development of tailored substance use and sexual risk reduction interventions for MSM.

MSM are avid Internet users (Grov, Breslow, Newcomb, Rosenberger, & Bauermeister, 2014) and many use the Internet (e.g., websites, chatrooms) to seek sex and substance use partners virtually (Bauermeister, Giguere, Carballo-Dieguez, Ventuneac, & Eisenberg, 2010; Halkitis, Fischgrund, & Parsons, 2005; Kubicek, Carpineto, McDavitt, Weiss, & Kipke, 2011). New technologies, such as geosocial networking applications (GSN apps) targeting MSM (e.g., G*rindr*, *Scruff*, *Jack'd*), have also emerged as important avenues through which MSM meet and maintain relationships with sex partners (Landovitz et al., 2013; Rice et al., 2012). These apps allow users to identify proximity of other users in real time, a feature that may increase engagement in risk behaviors (Winetrobe, Rice, Bauermeister, Petering, & Holloway, 2014). As relatively new technologies, much remains unknown about the relationship between GSN apps and MSM's social networks, whose composition is associated with MSM's sexual risk behavior (Berry, Raymond, & McFarland, 2007; Miller, Serner, & Wagner, 2005; Smith, Grierson, Wain, Pitts, & Pattison, 2004). The present study sought to document the social networks of MSM using a popular GSN app and to understand associations between individual and social network characteristics and substance use among GSN app-using MSM in Los Angeles, CA.

## Literature Review

### Substance Use and Abuse Among MSM

Substance use and sexual risk behaviors among MSM are intertconnected and contribute to health disparities among MSM (Stall & Purcell, 2000). MSM are at increased risk for both substance use and substance abuse (Kipke et al., 2007a; Moon, Fornili, & O'Briant, 2007), including the use of alcohol and marijuana (Russell, Driscoll, & Truong, 2002), cocaine, ecstasy and other club drugs (Kipke, et al., 2007b). In a study of 172 MSM recruited online, 49 % endorsed using club drugs (defined as crystal methamphetamine, ecstasy, poppers, cocaine and Viagra) and of those, 51 % used two or more at the same time and 25 % used three or more at the same time (Fernandez et al., 2005). Reviews on substance use and sexual risk behavior among MSM have demonstrated positive associations between alcohol use (Woolf & Maisto, 2009; Shuper, Joharchi, Irving, & Rehm, 2009), erectile dysfunction drugs (e.g., Viagra, Cialis) (Romanelli & Smith, 2004; Swearingen & Klausner, 2005), methamphetamine (Shoptaw & Reback, 2007; Halkitis, Parsons, & Stirratt, 2001) and sexual risk. However, the relationship between substance use and sexual risk behavior has been complicated by variations in how substance use is classified (e.g., "alcohol or drug use",

"multi-drug use" or "other drug use") and the time period under which substance use is measured (e.g., globally, situationally or at the event-level) (Leigh & Stall, 1993). A review of event-level measurement of substance use and sexual risk undertaken by Waverly Vosburgh and colleagues (2012) demonstrated consistent associations between binge alcohol use and sexual risk behaviors and methamphetamine use and sexual risk behaviors.

Studies of MSM in Los Angeles have documented high rates of substance use. For example, a comparative study of young MSM across 7 U.S. urban areas found that in Los Angeles recent substance use (in the past 6 months) included alcohol use (87 %), illicit drug use (67 %), "upper"/amphetamine use (32 %), and cocaine use (16 %). Of note was that 28 % of MSM reported using 3 or more different drugs in the past 6 months (Thiede et al., 2003). Another study compared substance use and HIV risk among MSM in Chicago and Los Angeles by serostatus and found that among HIV-positive men there were significantly higher rates of Viagra use in Los Angeles (Carey et al., 2009). Also, methamphetamine use was higher among men in Los Angeles compared to Chicago regardless of serostatus. A more recent study of young MSM in Los Angeles (ages 18–24 at baseline) found that 40 % reported frequent binge drinking, 40 % had ever used club drugs (defined as cocaine, crystal/methamphetamine, ecstasy, poppers, GHB, Ketamine, and other forms of speed) and 22 % were frequent or heavy cigarette smokers (Kipke et al., 2007a; Kipke et al., 2007b; Holloway et al., 2012). The association between alcohol use and sexual risk behavior, in particular, has been shown to vary across development and to be dependent upon the context in which it is used by MSM (Mustanski, 2008; Newcomb, 2013; Vanable et al., 2004).

## Social Networks and Substance Use Among MSM

Over the past two decades, there has been increasing interest in the ways in which social networks influence health behaviors (Smith & Christakis, 2008). Social networks refer to groups of individuals who are connected through personal relationships. Within social networks, members may influence another member's behavior based on social comparison, social sanctions and rewards, socialization, and information exchange (Fisher, 1988; Latkin et al., 1995). Social network analysis allows researchers to quantitatively document how individuals (i.e., egos) are connected to network members (i.e., alters) and the ways in which processes, such as social support and social influence, are transmitted through networks (Christakis & Fowler, 2008; Berkman & Glass, 2000). Network structure (e.g., size, density) and composition (e.g., proportion of types of social ties – family, friends, etc.) have been shown to influence health behaviors in a variety of populations (Smith & Christakis, 2008; Valente, 2010), including MSM (Smith, Grierson, Wain, Pitts, & Pattison, 2004; Peterson, Rothenberg, Kraft, Beeker, & Trotter, 2009; Tobin & Latkin, 2008).

Social network structure and composition have been linked to substance use. Latkin and colleagues (1995; 2003) demonstrated that social networks, norms, and HIV risk behaviors were linked among urban drug users at risk for HIV, finding that network density and size of drug subnetworks were associated with frequency of drug injection (Latkin, Mandell, Vlahov, Oziemkowska, & Celentano, 1995; Latkin, Forman, Knowlton, & Sherman, 2003). Their results also provided ways to intervene with specific social ties to improve norms around condom use. Other mechanisms through which social networks influence health

include social support to promote coping; engagement and interaction on a particular topic; exposure to new ideas, technologies, and access to other individuals or resources that could be potentially harmful or beneficial (e.g., connections to be able to obtain illegal drugs versus harm reduction strategies).

The notion that norms and behavior are "contagious" among social ties has gained momentum in studying the direct impact social networks have on a number of health behaviors, including binge drinking (Reifman, Watson, & McCourt, 2006), marijuana use (Kobus, & Henry, 2009), and illicit substance use (Schroeder et al., 2001). Social network homophily refers to the clustering of similar individuals within networks (McPherson, Smith-Lovin, & Cook, 2001). Studies of smoking and obesity have demonstrated that health behaviors often cluster in social networks (Christakis & Fowler, 2007; Christakis & Fowler, 2008). Egocentric network studies of young MSM have demonstrated that the presence of network members who engage in sexual risk behaviors is associated with greater sexual risk behavior among participants themselves (Amirkhanian et al., 2006; Tucker et al., 2012; Kapadia et al., 2013). However, to our knowledge, no studies have examined substance use homophily among MSM who use geosocial networking applications.

## Geosocial Networking Applications and Substance Use Among MSM

Technology has been recognized as an important avenue for implementing risk behavior prevention and health promotion among MSM, including young MSM (Allison et al., 2012; Holloway et al., 2014). Several studies published in recent years have focused on the use of GSN apps among MSM with a particular focus on motivations for GSN app use (Grosskopf, LaVasseur, & Glaser, 2014; Van De Wiele & Tong, 2014), sexual risk behaviors (Beymer et al, 2014, Rice et al., 2012; Lehmiller & Ioerger, 2014; Winetrobe, Rice, Bauermeister, Petering, & Holloway, 2014), HIV testing (Rendina, Jimenez, Grov, Ventuneac, & Parsons, 2014), and the acceptability of varied HIV prevention strategies among users (Burrell et al., 2012; Holloway et al., 2014; Landovitz et al., 2013). While none of these studies have focused explicitly on substance use, several have reported substance use prevalence among users. For example, among a sample of 146 young MSM (18–24 year old) GSN app users in Los Angeles, 64 % reported binge drinking, 35 % reported marijuana use and 26 % reported "hard drug" use (which included poppers, cocaine, heroin, methamphetamine and ecstasy) (Winetrobe, Rice, Bauermeister, Petering, & Holloway, 2014). Among an older sample of MSM (median age 25) in Los Angeles, Landovitz and colleagues (2013) found that 48 % of participants reported using drugs or alcohol during sex in the past month. Phillips and colleagues (2014) found that MSM who used GSN apps to look for other men in the past year were one and a half times more likely to have used non-injection drugs, including crystal methamphetamine, painkillers and poppers, compared to MSM who did not use GSN apps for partner seeking. To our knowledge, there are no published studies documenting correlates of substance use behaviors among GSN app-using MSM.

## Present Study

Given high rates of substance use and abuse among MSM, the important influence of social networks in determining substance use among MSM, and the emergence of new GSN apps to facilitate social networking among MSM, the present study sought to understand the

relationship between GSN app use, social network characteristics and substance use among MSM. Specifically, the following research questions were addressed: (1) “What is the composition of the social networks of GSN app-using MSM?” and (2) “Which individual and social network factors are associated with alcohol, marijuana and illicit substance use in this population?”

## Method

### Participants

MSM were recruited from two neighborhoods with large populations of gay and bisexually identified men in Los Angeles, CA: West Hollywood and Long Beach. Individuals were eligible to participate if they were users of a popular GSN app and had not previously participated in the study. Utilizing the geo-location feature of the GSN app, research assistants created their own profiles to recruit GSN app users who were within a seven-mile radius of West Hollywood and Long Beach, CA. From August 8, 2011 and October 3, 2011, GSN app users between the ages of 18–24 were recruited (young MSM). From December 5, 2011 and January 3, 2012, GSN app users 25 years of age and over were recruited (older MSM). The recruiters’ profiles contained the study institution’s name and identified the recruiters as researchers; their profile pictures were of the research assistant or a stock photo.

### Procedures

Participants were randomly selected based on their location at the time of recruitment. On the GSN app, profiles are organized by geo-location, with the first profiles being closest in proximity to the user. Users appeared on a grid displaying four profile photos in each row and continued for all users within a seven-mile range. Potential participants were selected using a randomization number chart displaying numbers between 1 and 4, to match the app’s profile display. Randomly selected persons were sent a message providing information about the study. Interested participants received a link and unique log-in code to an anonymous, online survey, which took approximately 20–30 minutes to complete. Upon completion, participants received a $25 downloadable gift card to either iCard or Amazon.com. For every user who was approached, his distance from the recruiter was recorded. Recruiters were available to answer respondents’ questions and to provide minor technical support through the GSN app’s chat feature. Recruitment occurred between 9 a.m. and 8 p.m. on weekdays. Overall, 11.95 % of the men approached via GSN app text message completed the survey resulting in a total sample of 295 participants. All study procedures were approved by the Institutional Review Board of the University of Southern California. Secondary data analysis for the present study was approved by the Institutional Review Board of the University of California, Los Angeles.

### Measures

The self-report survey was used to obtain a range of information from participants, including demographic characteristics, GSN app use characteristics, substance use and social network characteristics.

**Demographics—**Participants were asked to identify their age in years, race/ethnicity (African American, Latino/Hispanic, white, Asian, Native Hawaiian or other Pacific Islander, American Indian or Alaska Native, mixed race, other race). Native Hawaiian/ Pacific Islander, American Indian/Alaska Native, and other race were then collapsed to form one "Other" race category. Participants also reported highest level of education (less than high school, high school graduate or GED, some college, 4 year college/university degree, master's degree or professional degree, and doctorate); current employment status (not currently working, currently working); sexual identity (gay, bisexual, heterosexual, questioning, queer, other); whether they were out (i.e., had "disclosed having sex with other men") to parents, brothers/sisters, or other family; and their relationship status out of nine options, which were then collapsed to reflect whether the participant was single or not.

**GSN App Use—**Participants were asked how often they logged on to the GSN app (less than five times per day, five or more times per day); how long ago they started using the GSN app (less than one year, greater than one year); if their profile picture showed their face; what naked body parts were visible in their GSN app profile picture, which was dichotomized to reflect whether their profile picture showed their naked chest or abs or not; what time of day they usually logged on to the GSN app (before midnight, after midnight); and whether they used the GSN app both on weekdays and weekends. Participants were also asked whether they used the GSN app "to find people to drink or use drugs with" and whether "the last time [they] used the GSN app, was it during or immediately after [they] had been drinking alcohol or using drugs?"

**Substance use—**To assess binge drinking, participants were asked a question adapted from the Centers for Disease Control and Prevention Behavioral Risk Surveillance System (BRSS), "During the past 30 days, [have you] had 5 or more drinks of alcohol in a row (i.e., within a couple of hours) at least once?" To assess illicit substance use, participants were asked to report on the frequency of their past 30 day use of marijuana, poppers, heroin, methamphetamine and ecstasy (0 days, 1 or 2 days, 3 to 5 days, 6 to 9 days, 10 to 19 days, 20 to 29 days, All 30 days). Responses were subsequently collapsed and dichotomized to reflect at least one episode of marijuana use and one episode of recent illicit drug (i.e., poppers, heroin, methamphetamines, ecstasy) use.

**Social Networks—**A single-item egocentric name generator asked participants to list their top five closest social network members (i.e., alters) using the following prompt: "The next several questions are about the most important people that you regularly communicate with on a social basis. These are people that you interact with, either through face-to-face contact or via the Internet or cell phone and could be family members, friends, sex-partners, co-workers or anyone else who is important to you. Based on this criteria, we ask that you please list the five people you interact with the most and/or who are most important to you in the space provided below." Participants gave a first name or nickname for each alter; last names were not gathered to preserve confidentiality of nominated alters. Next, participants were asked to describe their relationship to each alter (e.g., life partner/husband, boyfriend, lover/sex partner/hook-up, family, friend, coworker, other) and the age, race/ethnicity, and sexual orientation of that alter. Alters described as husband, boyfriend, lover, sex partner

and hook-up were grouped to represent “intimate partners”. In addition, participants were asked to report whether they had known each network alter for more than a year, whether they provided the participant with emotional support (i.e., “anyone who you can go to if you have an important problem to discuss about your personal life”), and whether they provided the participant with instrumental support (i.e., “anyone who you could borrow $100 from if you needed it”).

Alters’ substance use was assessed by asking participants to select any of their alters who had engaged in recent alcohol, marijuana or illicit substance use. Specifically, participants were asked the following questions: (1) “In the past month, who has drunk alcohol to the point of drunkenness?”; (2) “In the past month, who smoked marijuana, pot, or weed?”; (3) “In the past month, who used meth, crystal, or Tina?”; (4) “In the past month, who used cocaine?”; and (5) “In the past month, who used heroin?” All responses were scored dichotomously. An additional dichotomous item representing illicit drug use (methamphetamines, cocaine, heroin) was created. Participants were also asked which of their network members would object to them “drinking to the point of drunkenness,” “smoking marijuana” or using any of the other substances named above.

### Statistical Analysis

Bivariate tests of association (i.e., chi square, independent sample t-test) determined associations between individual level variables (i.e., demographic variables, GSN app use) and whether the participant had included a GSN app-met partner in his network. Associations between individual and social network characteristics and each of the three substance use outcomes (i.e., binge drinking, marijuana use, illicit substance use) were determined using chi square tests of association. In social network analyses, family member alters were excluded from the total sample of alters because a primary aim of this analysis was to determine differences between GSN app-met and non-GSN app-met alters and family members were unlikely to be met through the GSN app. Due to the large number of tests that were conducted, we employed the false discovery rate controlling procedure described by Benjamini and Hochberg (1995). Multivariate logistic regressions were also performed to simultaneously test for associations between individual- and network-level factors and substance use outcomes. All data were analyzed using SAS 9.2 (2011).

## Results

### Individual Characteristics

Table 1 presents demographic characteristics, GSN app use and substance use behaviors for the total sample (N = 295) by whether the participant included a GSN app-met partner in his network (N = 62) or not (N = 226). In general, participants were young (mean age = 25.56), educated (i.e., had completed some college or more at the time of the study) (88.82 %), single (81.36 %), gay-identified (90.14 %), and out to their families (81.69 %). White men made up the largest racial/ethnic group (51.53 %); smaller percentages of the sample were Latino/Hispanic (23.39 %), Asian (10.17 %), and Black/African American (4.41 %). Most were employed (70.85 %). About half of the sample reported using the GSN app for over one year (46.53 %), logged on five or more times per day (50.69 %) and logged on after

midnight (52.20 %). Less than one third showed their naked chest or abs in their profile picture (29.62 %), approximately 10 % used the GSN app to find alcohol or substance using partners and approximately 8 % reported using the GSN app immediately after using alcohol or drugs. Over half reported recent binge drinking (59.32 %); over a third reported recent marijuana use (36.81 %); over a quarter reported using one or more illicit drug in the past month (26.44 %) or being under the influence of alcohol or drugs during their last sexual encounter (26.96 %). Additionally, over three-quarters of the sample had at least one network member who drank alcohol to the point of drunkenness (77.14 %), slightly more than half had at least one network member who used marijuana (55.00 %), and less than a quarter had at least one network member who used any illicit substances (22.92 %).

A number of statistically significant differences emerged between participants who included a GSN app-met partner in their social network and those who did not (Table 1). A smaller percentage of participants with a GSN app-met partner in their social network were single compared to those without a GSN app-met partner in their network (72.58 % versus 84.07 %, $X^2 = 4.28$, $p < 0.05$). Additionally, a greater percentage of participants with a GSN app-met partner in their network reported having sex under the influence of drugs or alcohol with a GSN app-met partner versus those who did not include a GSN app-met partner in their social network (32.29 % versus 17.04 %, $X^2 = 7.31$, $p < 0.01$). Finally, a greater percentage of participants with a GSN app-met partner in their social network also had at least one person who drinks to the point of drunkenness included in their social network compared to those who did not include a GSN app-met partner in their social network (86.67 % versus 74.55 %, $X^2 = 3.93$, $p < 0.05$).

## Social Network Characteristics

Excluding family members, MSM nominated a total of 1,239 alters, which included friends (76.42 %), intimate partners (15.96 %), co-workers (3.65 %) and others (2.76 %). A greater percentage of GSN app-met partners were male (98.80 % vs. 64.22 %, $X^2 = 41.49$, $p < 0.001$), LGBT-identified (98.84 % vs. 60.67 %, $X^2 = 50.09$, $p < 0.001$), and intimate partners (52.87 % vs. 13.23 %, $X^2 = 94.00$, $p < 0.001$). More non-GSN app-met partners were friends (78.64 % vs. 43.68 %, $X^2 = 54.29$, $p < 0.001$) had known participants for longer than one year (78.56 % vs. 27.59 %, $X^2 = 111.59$, $p < 0.001$) and provided emotional (65.09 % vs. 42.53 %, $X^2 = 17.71$, $p < 0.001$) and instrumental support (54.16 % vs. 41.18 %, $X^2 = 5.34$, $p < 0.02$) to participants. There were no statistically significant differences in substance use behavior or objecting to substance use between alters met via GSN app vs. alters met elsewhere (Table 2).

## Substance Use Outcomes

**Binge Drinking—**Bivariate associations between individual characteristics, social network characteristics and substance use outcomes are presented in Table 3. Only two individual-level characteristics were associated with binge drinking: White race/ethnicity and having completed at least some college or university ($p < 0.05$). At the network level, GSN app use and instrumental support were also associated with binge drinking ($p < 0.05$). Additionally, the proportion of alters who objected to participants' drinking to the point of drunkenness, as well as whether alters drank alcohol to the point of drunkenness, smoked marijuana and used

an illicit substance were associated with binge drinking ($p < 0.05$). In multivariate analyses (not shown) greater educational attainment (AOR = 0.51; 95 % CI = 0.29–0.91) and the proportion of network members who would object to the participant getting drunk (AOR = 0.34; 95 % CI = 0.13–0.92) were protective against binge drinking. The strongest predictor of participants' recent binge drinking was having at least one alter who drinks alcohol to the point of drunkenness in their network (AOR = 3.81; 95 % CI = 1.86–7.80).

**Marijuana Use—**The only individual-level predictor associated with recent marijuana use was GSN app use for more than one year ($p < 0.05$). At the social network level, recent marijuana use was associated with knowing their network members for greater than one year and having network members who provide instrumental support ($p < 0.05$). Recent marijuana use was negative associated with the proportion of network members who objected to them smoking marijuana and positively associated with whether network members drank alcohol to the point of drunkenness, smoked marijuana, and used an illicit substance ($p < 0.05$). In multivariate analyses, the proportion of network members who objected to smoking marijuana was protective against recent marijuana use (AOR = 0.18, 95 % CI = 0.06–0.56). A greater proportion of network members who provided instrumental support increased the odds of recent marijuana use (AOR = 2.52; 95 % CI = 1.04–6.12) as did having at least one alter who smokes marijuana (AOR = 4.12; 95 % CI = 2.22–7.64).

**Illicit Drug Use—**At the individual level, age and white race/ethnicity were both associated with recent illicit substance use ($p < 0.05$). Additionally, GSN app use greater than one year and displaying their naked chest or abs in their GSN app profile picture were associated with recent illicit substance use ($p < 0.05$). At the network-level, having older, male, white, gay-identified and GSN app-met alters in one's network were also associated with having used an illicit drug in the past 30 days, as was having network members with whom participants "hook up" in their network. Having alters who provided instrumental support was also associated with recent illicit substance use ($p < 0.05$). Recent illicit substance use was negatively associated with the proportion of alters who objected to using illicit substance and was positively associated with whether alters drank to the point of drunkenness and used illicit substances ($p < 0.05$). The only statistically significant predictor of participants' illicit substance use in multivariate analyses was having at least one alter who uses any illicit substance in their social network (AOR = 6.45; 95 % CI = 3.26–12.79).

## Discussion

This study is among the first to examine the social networks of GSN app-using MSM in relation to substance use. Similar to other samples of MSM in Los Angeles, rates of binge drinking, marijuana use and illicit substance use were high (Kipke et al., 2007a; Thiede et al., 2003), demonstrating the need for increased substance use/misuse prevention with MSM. Our first research question sought to identify the composition of the social networks of GSN app using MSM. Results indicate diversity in the composition of GSN app users' networks, which are comprised of friends, intimate partners, family members (although excluded for this analysis), co-workers and others. While results indicate that a small subsample of MSM used the GSN app to find partners with whom to drink alcohol and use substances (approximately 10 %), large percentages of the GSN app-users had network

members who engaged in binge drinking, marijuana use and illicit substance use. Results from the present study may inform network-based interventions targeting these behaviors that are staged via GSN apps, which may be especially useful in reducing substance use/misuse among MSM given the popularity and widespread use of these apps.

Over one fifth of participants in the present study included a GSN app-met alter as a member of their closest social network and statistically significantly higher percentages of GSN app-met alters belonged to participants who had used the technology for greater than one year. GSN app-met network members were more likely to be “hook ups” than social network members met elsewhere, demonstrating, as has been shown by others (Rice et al., 2012), that sexual partner seeking is a primary purpose for using the GSN app. It is important to note that 12 % of GSN app-met alters were classified as husbands, life partners or boyfriends and 44 % were classified as friends. The popular press has characterizes GSN apps as platforms for casual sex seeking (Kapp, 2011; Wortham, 2013). While this is true for many GSN app-users, it is also true that primary romantic relationships and close friendships are formed via GSN apps. As such, these platforms represents important gay male social context for dating, serious relationship and friendship seeking. While larger percentages of alters providing emotional and instrumental social support were met elsewhere, over 40 % of alters met on the GSN app provided social support to participants.

Our second research question sought to understand the influence of individual and social network factors on engagement in binge drinking, marijuana use and illicit substance use. Despite the pro-social roles that GSN app-met alters held in the lives of participants in this study, there were some individual-level GSN app use patterns that emerged as correlates of substance use outcomes. Specifically, older age, higher education and white race/ethnicity were associated with greater substance use. Furthermore, using the GSN app for longer than one year was correlated with recent use of marijuana and illicit substances. Finally, displaying naked chest or abs in their GSN app profile photos was associated with illicit substance use. These findings at the individual level are similar to those of Winetrobe and colleagues (2014) who analyzed data from the young men (ages 18–24) in this sample and found that those who had used the GSN app longer and displayed sexualized profile photos were more likely to have engaged in unprotected anal intercourse with their last GSN app-met partner. Taken together, these findings may indicate heightened risk behaviors for a subset of GSN app-users. However, the addition of network data presented here suggests that for substance use outcomes this heightened risk is primarily function of social network dynamics, rather than individual-level risk behaviors, as the strongest predictors of binge drinking, marijuana use and illicit substance use were presence of a social network member who also engaged in these behaviors.

Social network results from this study emphasize the importance of network influence on substance use, as has been shown by others. Participants with alcohol users, marijuana users and illicit substance users in their networks were more likely to engage in those behaviors themselves. Described by McPherson (2001), this phenomenon is referred to as homophily and refers to the idea that like individuals are more likely to affiliate with others who are similar to themselves (i.e., “birds of a feather flock together”). These results are intuitive given the powerful influence of peer norms and the fact that substance use among MSM

often occurs in groups and social settings (Halkitis et al., 2011). Because our data is cross sectional it is impossible for us to determine whether substance users seek out other substance users for inclusion into their networks or whether peer influence processes operate within networks to promote greater substance use. Further longitudinal research with GSN app-using MSM should attempt to elucidate these processes over time, as their clarification may have important implications for preventing substance abuse and related risks among GSN app-using MSM.

A key finding for the development of risk behavior prevention and harm reduction interventions is the protective nature of having a social network member who objects to binge drinking, marijuana use and illicit substance use. Network studies of young MSM have demonstrated lower levels of sexual risk behaviors among participants who have a "pro-social" peer as part of their social network. Tucker and colleagues (2012) found that homeless YMSM were less likely to engage in unprotected sex and had fewer sex partners if their networks included fewer sex partners and if the majority of their network members were not heavy drinkers (i.e., greater than 50% had not drank alcohol to the point of drunkenness in the past 30 months). Social network based interventions that take into consideration the composition of MSM networks, leverage ties to peers who do not engage in risk behaviors and promote diffusion of peer norms that are discouraging of substance use and related risks may be especially effective (Valente, 2012).

## Limitations

Limitations of the present research should be taken into consideration when interpreting findings. As mentioned above, this was a cross-sectional study, making it impossible to determine the direction of our findings or causality. Furthermore, our study did not include a comparison group of non-GSN app users, making it impossible to determine whether substance use is comparable between users and non-users. All data were collected via self-report, which may underestimate or overestimate the actual prevalence of binge drinking, marijuana use and illicit substance use. Enabling MSM to take the survey using their private computers, smartphones or tablets likely contributed to veracity in reporting of behaviors; however, it is impossible to know for certain. In addition, we gathered data on the attitudes of participants' social network members from the participants themselves, without consulting nominated network members. It is quite possible that participants' perceptions of the attitudes and behaviors of their network members do not correspond to actual behavior. However, several studies have demonstrated the importance of perception of peer behavior on the actual risk behavior of participants, so this may be less of a concern for many readers (Peterson et al., 2009; Hart & Peterson, 2004).

The recruitment methods used (i.e., active recruitment, recruitment of younger MSM and older MSM at different times, and limiting recruitment to just one popular GSN app in Los Angeles, CA) could also have introduced bias and limit the generalizability of our results, especially if there are underlying differences between those who were available or not available to participate in the study during the recruitment periods, for example. The large numbers of white, well-educated participants is likely a function of recruiting in affluent gay neighborhoods in Los Angeles (i.e., West Hollywood, Long Beach). Future research with

racial/ethnic minority and low-income GSN app users is needed. Additionally, because contact with GSN app representatives could not be made, we were unable to develop a fully collaborative research approach. As noted in previous work, collaborative approaches between GSN app companies and public health researchers are warranted to fully elucidate the role that GSN apps play in the lives of MSM (Holloway et al., 2014).

### Conclusions

Despite the limitations of this study, the findings may have useful implications for the formulation of substance use/misuse prevention interventions for GSN-app using MSM. First, due to the widespread use of these technologies and high prevalence rates of binge drinking, marijuana use and illicit substance use among GSN app users, it appears that these platforms may be well suited for the dissemination of prevention and harm reduction messaging. Our previous research suggests high levels of acceptability of HIV prevention interventions delivered via smartphone among young MSM (Holloway et al., 2014); however, no research has been conducted on the acceptability of substance abuse prevention interventions in these contexts. Formative research is needed on the feasibility of app-based prevention interventions with this population as little is known about how MSM may respond to these efforts. Banner ads and push notifications can be easily purchased on GSN apps to remind users of relevant information regarding substance use and accompanying sexual risk behaviors (e.g., using substances during sex increases one's risk for contracting HIV); however, it is unclear how effective these approaches may be in capturing the attention of MSM using GSN apps.

Network homophily among GSN app-using MSM points to the possibility of network based interventions that can promote peer norms to discourage substance misuse. Facebook-delivered popular opinion leader models to increase HIV testing have been successful with racially and ethnically diverse MSM previously (Young et al., 2014). Similar interventions implemented via GSN apps may be protective against substance misuse among GSN app-using MSM. Finally, those interested in promoting health behaviors among GSN app-using MSM must bear in mind that GSN apps are used for much more than substance use and/or casual sex partner seeking; instead, GSN apps represent important social contexts for affiliation between gay, bisexual and other MSM. Recognition of the important social role that GSN apps play in the lives of MSM will assist public health practitioners to develop interventions that promote positive affiliation while reducing high-risk behaviors.

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**Table 1**

Demographic characteristics by whether the participants included a GSN app-met partner in their social network. (N = 295)[a]

| | App-met partner in network (n = 62) | | No app-met partner in network (n = 226) | | Total (n = 295) | | | |
|---|---|---|---|---|---|---|---|---|
| **Variable** | **N** | **% or Mean (SD)** | **N** | **% or Mean (SD)** | **N** | **% or Mean (SD)** | **$X^2$ or t Statistic** | **p value** |
| Age | 62 | 25.94 (6.56) | 226 | 25.58 (6.61) | 295 | 25.56 (6.56) | | |
| Race/Ethnicity[a] | | | | | | | 0.2404 | .6240 |
| White | 34 | 54.84 | 116 | 51.33 | 152 | 51.53 | | |
| Black/AA | 2 | 3.23 | 11 | 4.87 | 13 | 4.41 | | |
| Latino/Hispanic | 13 | 20.97 | 53 | 23.45 | 69 | 23.39 | | |
| Asian | 5 | 8.06 | 24 | 10.62 | 30 | 10.17 | | |
| Mixed | 7 | 11.29 | 20 | 8.85 | 28 | 9.49 | | |
| Other | 1 | 1.61 | 2 | 0.88 | 3 | 1.02 | | |
| Sexual Orientation[b] | | | | | | | 1.1420 | 0.2852 |
| Gay | 58 | 93.55 | 201 | 88.94 | 265 | 90.14 | | |
| Bisexual | 4 | 6.45 | 17 | 7.56 | 22 | 7.48 | | |
| Straight | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | | |
| Questioning | 0 | 0.00 | 4 | 1.78 | 4 | 1.36 | | |
| Queer | 0 | 0.00 | 1 | 0.44 | 1 | 0.34 | | |
| Other | 0 | 0.00 | 2 | 0.89 | 2 | 0.68 | | |
| Education[c] | | | | | | | 0.0009 | 0.9755 |
| < High school | 1 | 1.61 | 4 | 1.77 | 5 | 1.69 | | |
| High school GED | 8 | 12.90 | 18 | 7.96 | 28 | 9.49 | | |
| Some college | 24 | 38.71 | 87 | 38.50 | 115 | 38.98 | | |
| 4 year college | 20 | 32.26 | 91 | 40.27 | 112 | 37.97 | | |
| Master's degree | 9 | 14.52 | 21 | 9.29 | 30 | 10.17 | | |
| Doctorate | 0 | 0.00 | 5 | 2.21 | 5 | 1.69 | | |
| Employed | 45 | 72.58 | 158 | 69.91 | 209 | 70.85 | 0.1666 | 0.6831 |
| "Out" to family members | 52 | 83.87 | 184 | 81.42 | 241 | 81.69 | | |
| Single*[d] | 45 | 72.58 | 190 | 84.07 | 240 | 81.36 | 4.276 | 0.0386 |
| *GSN app* Use | | | | | | | | |

| Variable | App-met partner in network (n = 62) | | No app-met partner in network (n = 226) | | Total (n = 295) | | $X^2$ or t Statistic | p value |
|---|---|---|---|---|---|---|---|---|
| | N | % or Mean (SD) | N | % or Mean (SD) | N | % or Mean (SD) | | |
| Use 5 + times/day | 35 | 56.45 | 111 | 49.12 | 146 | 50.69 | 1.0477 | 0.3060 |
| Use > 1 year* | 37 | 59.68 | 97 | 42.92 | 134 | 46.53 | 5.4911 | 0.0191 |
| Chest/abs showing | 21 | 33.87 | 64 | 28.44 | 85 | 29.62 | 0.6866 | 0.4073 |
| Use after midnight | 35 | 56.45 | 117 | 51.77 | 152 | 52.78 | 0.4279 | 0.5130 |
| Use to find substance users* | 12 | 19.35 | 17 | 7.52 | 29 | 10.07 | 7.5225 | 0.0061 |
| Use after alcohol / drug use^ | 4 | 6.45 | 19 | 8.41 | 23 | 7.99 | -- | -- |
| Last sex under influence of alcohol/drugs | 21 | 33.87 | 55 | 24.55 | 79 | 29.96 | 2.1605 | 0.1416 |
| Recent Substance Use | | | | | | | | |
| Binge drinking | 35 | 56.45 | 135 | 59.73 | 175 | 59.32 | 0.2168 | 0.6415 |
| Marijuana use | 19 | 31.15 | 82 | 37.27 | 106 | 36.81 | 0.7782 | 0.3777 |
| Illicit[e] drug use | 20 | 32.26 | 56 | 24.78 | 78 | 26.44 | 1.4011 | 0.2365 |
| Has at least one alter who: | | | | | | | | |
| Drinks alcohol to drunkenness* | 52 | 86.67 | 164 | 74.55 | 216 | 77.14 | 3.9282 | 0.0475 |
| Smokes marijuana | 33 | 53.23 | 121 | 55.50 | 154 | 55.00 | 0.1013 | 0.7503 |
| Uses any illicit substance | 17 | 27.42 | 49 | 21.68 | 66 | 22.92 | 0.9036 | 0.3410 |

*p < .05

**p < .01

***p < .001

^Contains cells with < 5 expected counts

[a]May not add up to total sample size due to missing values

[b]$X^2$ test: White vs. all others

[c]$X^2$ test: Gay/Homosexual vs. all others

[d]$X^2$ test: Some college or university vs. all others

[e]$X^2$ test: Single vs. all others

[f]Includes poppers, cocaine, heroin, methamphetamines and/or ecstasy

**Table 2**

Bivariate comparisons of GSN app-met social network members and non-GSN app-met social network members (N=1239, excludes family alters)[a]

| | GSN app-met (n = 87) | | Non-GSN app-met (n = 1124) | | Total (n = 1239) | | | |
|---|---|---|---|---|---|---|---|---|
| **Variable** | **N** | **% or Mean (SD)** | **N** | **% or Mean (SD)** | **N** | **% or Mean (SD)** | **$X^2$ or t Statistic** | **p value** |
| Age | 87 | 29.56 (8.41) | 1089 | 28.49 (8.85) | 1204 | 28.47 (8.81) | -1.0900 | 0.2763 |
| Male*** | 82 | 98.80 | 700 | 64.22 | 798 | 66.44 | 41.4900 | <.0001 |
| Race/Ethnicity[b] | | | | | | | 0.3846 | 0.5352 |
| White | 43 | 49.43 | 581 | 52.91 | 641 | 52.93 | | |
| Latino/Hispanic | 22 | 25.29 | 273 | 24.86 | 301 | 24.86 | | |
| Asian | 11 | 12.64 | 117 | 10.66 | 128 | 10.57 | | |
| Pacific Islander | 2 | 2.30 | 10 | 0.91 | 12 | 0.99 | | |
| AI/Alaska Native | 0 | 0.00 | 7 | 0.64 | 8 | 0.66 | | |
| Mixed | 2 | 2.30 | 34 | 3.10 | 37 | 3.06 | | |
| Other | 1 | 1.15 | 3 | 0.27 | 4 | 0.33 | | |
| LGBT*** | 85 | 98.84 | 668 | 60.67 | 770 | 63.37 | 50.0939 | <.0001 |
| Relationship | | | | | | | | |
| Intimate*** | 46 | 52.87 | 148 | 13.23 | 197 | 15.96 | 94.0038 | <.0001 |
| Life partner^ | 2 | 2.30 | 20 | 1.79 | 22 | 1.78 | -- | -- |
| Boyfriend** | 10 | 11.49 | 46 | 4.11 | 57 | 4.62 | 9.9387 | 0.0016 |
| Hook-up*** | 34 | 39.08 | 82 | 7.33 | 118 | 9.56 | 91.2882 | <.0001 |
| Friend*** | 38 | 43.68 | 880 | 78.64 | 943 | 76.42 | 54.2864 | <.0001 |
| Coworker^ | 1 | 1.15 | 44 | 3.93 | 45 | 3.65 | -- | -- |
| Other^ | 2 | 2.30 | 32 | 2.86 | 34 | 2.76 | -- | -- |
| Known > 1 year*** | 24 | 27.59 | 883 | 78.56 | 921 | 74.33 | 111.5889 | <.0001 |
| Uses GSN app*** | 87 | 100.00 | 269 | 24.75 | 354 | 29.77 | 154.54 | <.0001 |
| Support provided Emotional*** | 37 | 42.53 | 727 | 65.09 | 783 | 63.56 | 17.7088 | <.0001 |
| Instrumental* | 35 | 41.18 | 593 | 54.16 | 642 | 53.15 | 5.3368 | 0.0209 |
| Objects to: | | | | | | | | |

| | GSN app-met (n = 87) | | Non-GSN app-met (n = 1124) | | Total (n = 1239) | | $X^2$ or t Statistic | p value |
|---|---|---|---|---|---|---|---|---|
| **Variable** | **N** | **% or Mean (SD)** | **N** | **% or Mean (SD)** | **N** | **% or Mean (SD)** | | |
| Getting drunk | 9 | 10.34 | 178 | 16.45 | 188 | 15.71 | 2.2343 | 0.1350 |
| Marijuana | 15 | 17.44 | 229 | 21.34 | 248 | 20.96 | 0.7287 | 0.3933 |
| Illicit substance[c] | 74 | 85.06 | 929 | 82.65 | 1103 | 82.82 | 0.3287 | 0.5665 |
| Gets drunk | 45 | 52.94 | 464 | 42.45 | 523 | 43.51 | 3.5361 | 0.0600 |
| Smokes marijuana | 16 | 18.39 | 257 | 23.60 | 277 | 23.18 | 1.2263 | 0.2681 |
| Uses Illicit substance[c] | 8 | 9.20 | 96 | 8.54 | 106 | 8.56 | 0.0441 | 0.8337 |

*p < .05

**p < .01

***p < .001

^Contains cells with < 5 expected counts

[a]Sample sizes may vary due to missing data

[b]$X^2$ test: White vs. all others

[c]Includes cocaine, heroin and/or methamphetamines

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**Table 3**

Bivariate comparisons of recent substance use outcomes by individual- and network-level characteristics

| | Binge Drinking % (n) | Marijuana Use % (n) | Illicit Substance Use % (n) |
|---|---|---|---|
| *Individual-level (n = 295)* | | | |
| 25 years of age or older | 33.71 (59) | 33.96 (36) | 47.44 (37)* |
| White race/ethnicity | 60.00 (105)* | 55.66 (59) | 66.67 (52)* |
| Gay/Homosexual Sexual Orientation | 90.86 (159) | 86.79 (92) | 92.31 (72) |
| Some college or university | 32.00 (56)* | 41.51 (44) | 38.46 (30) |
| Employed | 72.57 (127) | 70.75 (75) | 74.36 (58) |
| "Out" to family | 82.29 (144) | 84.91 (90) | 84.62 (66) |
| Single | 84.00 (147) | 76.42 (81) | 79.49 (62) |
| *GSN app* Use | | | |
| Use 5 + times/day | 48.57 (85) | 48.11 (51) | 52.56 (41) |
| Use > 1 year | 49.14 (86) | 39.62 (42)* | 57.69 (45)* |
| Chest/abs showing | 31.03 (54) | 31.43 (33) | 41.56 (32)* |
| Use after midnight | 52.57 (92) | 53.77 (57) | 52.56 (41) |
| Includes app-met partner in SN | 20.59 (35) | 18.81 (19) | 26.32 (20) |
| *Network-level (n = 1239, excludes family alters)* | | | |
| Alter met via GSN app | 7.07 (51) | 6.24 (27) | 8.08 (27) |
| 25 years of age or older | 57.09 (423) | 54.55 (246) | 67.25 (230)* |
| Male | 66.34 (477) | 65.75 (286) | 74.02 (245)* |
| White race/ethnicity | 53.58 (397) | 53.22 (240) | 60.82 (208)* |
| LGBT Sexual Orientation | 64.75 (474) | 60.64 (265) | 69.28 (230)* |
| Relationship with Alter | | | |
| Intimate | 15.25 (113) | 15.74 (71) | 18.71 (64) |
| Life partner/husband | 1.62 (12) | 1.55 (7) | 2.63 (9) |
| Boyfriend | 4.59 (34) | 5.76 (26) | 3.80 (13) |
| Hook-up | 9.04 (67) | 8.43 (38) | 12.28 (42)* |
| Friend | 77.33 (573) | 75.17 (339) | 73.39 (251) |
| Coworker | 3.91 (29) | 4.88 (22) | 4.09 (14) |

| | Binge Drinking % (n) | Marijuana Use % (n) | Illicit Substance Use % (n) |
|---|---|---|---|
| Other | 2.70 (20) | 1.77 (8) | 1.75 (6) |
| Known > 1 year | 75.03 (556) | 78.27 (353)* | 76.02 (260) |
| Uses GSN app | 32.87 (237)* | 31.55 (136) | 37.69 (124)* |
| Support provided | | | |
| Emotional support | 64.91 (481) | 65.70 (293) | 60.83 (205) |
| Instrumental support | 56.87 (418)* | 59.73 (261)* | 61.18 (197)* |
| Alter would object to you: | | | |
| Getting drunk | 10.80 (77)* | – | – |
| Smoking marijuana | – | 9.43 (40)* | – |
| Using illicit substance[a] | – | – | 77.78 (266)* |
| Substance use among alters | | | |
| Drinks alcohol to Drunkenness | 54.84 (402)* | 51.47 (228)* | 52.69 (176)* |
| Smokes marijuana | 27.25 (197)* | 36.16 (158)* | 26.77 (87) |
| Any illicit substance use[a] | 11.88 (88)* | 12.42 (56)* | 21.35 (73)* |

*p < .05

[a]Includes cocaine, heroin and/or methamphetamines

Note: Independent sample t-test used for continuous predictors; chi-square or Fisher's exact used for categorical predictors. Multiple comparisons adjusted using the Benjamini and Hochman (1995) procedure.