

Substance use and HIV risk behavior among  
black South African men who have sex with men

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## ABSTRACT

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Black South African men who have sex with men (MSM) face a set of adverse circumstances, including economic hardship and stigmatization, that combine to put them at an elevated risk for hazardous substance use and HIV infection. This creates a context where substance use is normative and high-risk sexual behavior is often engaged in covertly and under the influence of intoxicating substances. The overarching objective of this dissertation was to explore determinants of hazardous drinking and HIV risk behavior among black South African MSM with a particular focus on the role of social networks. In order to achieve this, I used data drawn from the study, "HIV and Sexual Risk in African MSM in South African Townships" (R01-MH083557; PI: Sandfort, PhD). First, I conducted a systematic literature review to identify studies that used social network analysis to evaluate alcohol use among adults in order to answer the question: how have social network characteristics been shown to influence adults' drinking behaviors, both in terms of characteristics of their network structures and characteristics of their network ties? Results of the review demonstrated that characteristics of one's peers as well as social network structure influenced egos' alcohol consumption in a variety of ways and across settings. Second, I described drug and alcohol use among black South African MSM and identified determinants of hazardous drinking, a highly prevalent form of alcohol use identified in the sample. The results showed that hazardous drinking was highly prevalent and multiple indicators of social vulnerability were identified as independent determinants of hazardous drinking. Third, I assessed the relationship between substance use and sexual risk behavior and explored the moderating effects of psychosocial factors. The results showed that there was not a

main effect between substance use and sexual risk behavior; however, among men with high intentions to engage in safer sex, substance use was associated with increased risky sexual behavior. Overall, this dissertation increased our understanding of social networks, substance use and HIV risk behavior among black South African MSM. Our results suggest the importance of using pre-existing social networks to deliver potential interventions. The results also suggest that the most vulnerable members of this community are at increased risk of hazardous drinking. Lastly, efforts to reduce HIV risk behavior should focus on both increasing safer sex intentions and negating the impact of substance use on sexual risk behavior. Taken together, these studies provide insight for developing potential interventions, including intervention that use social network data to facilitate behavioral change, as well as undertaking further research among a critical population.

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## **Chapter 1 Introduction**

### **Background**

Black South African men who have sex with men (MSM) face a set of circumstances that put them at an elevated risk for hazardous drinking and HIV infection. The majority of black South Africans reside in townships, peri-urban areas previously segregated under Apartheid that are characterized by limited resources, low levels of education, and high rates of unemployment (1).

Black South African MSM suffer further deprivation because of the discrimination and stigma they face due to their sexual preferences (2, 3). Institutional channels, (e.g., civic or commercial institutions, such as Lesbian-Gay-Bisexual-Transgender (LGBT) community organizations) through which these men can interact are relatively scarce. There is no commercial gay subculture, save a few exceptions (i.e., in major metropolitan areas like Cape Town and Johannesburg). Therefore, black South African MSM are forced to meet other men through social networks, by traveling to gay clubs outside of the townships where many of them live, or going to informal drinking establishments (shebeens). These circumstances combine to create a context where substance use, particularly hazardous drinking, is normative and high-risk sexual behavior is often engaged in covertly and under the influence of intoxicating substances.

Accordingly, black South African MSM suffer from a disproportionate burden of hazardous drinking and HIV infection (4-13).

Social networks, sets of individuals linked together by one or more specific types of relations (14, 15), are of great importance to their members (16). Members of a shared social network influence each other by sharing information, expressing support, and creating social norms (17-20). In South Africa, where there is no commercial gay subculture (e.g. gay friendly bars and clubs) except for in a few major metropolitan areas (i.e. Cape Town and Johannesburg), social

networks are the primary context in which MSM learn how to express their sexuality, deal with stigma, and manage the risks of unprotected sex (21). Black South African MSM communities, particularly those in townships, mainly consist of geographically dispersed and often hidden social networks. Because they lack the identifiable civic and business institutions that characterize better-resourced MSM communities of urban North America, Western Europe, Australia, or even those of South Africa's urban centers, these men are less effectively targeted through community venues and organization-based approaches to health promotion that have been institutionalized elsewhere. Due to the limited education and resources, and stigmatization of homosexuality, MSM often seek members of their personal network for trusted information and advice. Social networks can also play a major role in persistence of unhealthy behaviors (22-29). Research has documented associations between social norms and behaviors such as drug use (30), alcohol use (31, 32), smoking (33), and needle-sharing (17). The composition and characteristics of networks have also been linked to sexual risk behaviors (number of sexual partners, incidences of unprotected sex) (34), and networks have been shown to facilitate the spread of sexually transmitted infections (STI's) (35-39). Given the potential importance of social networks in this setting, a comprehensive, systematic review of the literature that describes the application of social network analysis to the evaluation of alcohol use among adults (a salient health issue among this population) in previous scientific investigations is needed.

Despite the known burden of substance use, particularly hazardous drinking, and its association with health risks, no study to date has identified risk factors for hazardous drinking among black South African MSM, nor any other African MSM population (40). Researchers have observed elevated rates of concurrent psychosocial problems, including heavy alcohol use, among non-African LGBT populations (41-46), noting that they work synergistically to increase risk of HIV

infection (46, 47). For example, mental health problems, including anxiety (48), and depression (49), often co-occur with substance use disorders, particularly alcohol dependence (43). Sexual minority stressors, such as internalized homophobia and external homophobia (i.e. experiences with sexual orientation-related discrimination), are associated with increased alcohol-related problems (43, 44), and are likely of heightened importance among black South African MSM where same-sex sexuality is highly stigmatized (50-55). All of these factors need to be explored as potential determinants of hazardous drinking among black South African MSM. Social network characteristics are also potential determinants of hazardous drinking as social networks are known to play a major role in many health-related behaviors (18, 24, 28, 34, 37, 39, 56). For example, the drinking behavior of an individual's social network members often provides a crucial context for individual decisions on how much and how often to drink (57). One's degree of connectedness to a specific social network has been found to be positively associated with one's likelihood of reflecting the normative behavior of that group regarding substance use (58). Peers' alcohol use has been found to be a primary influence on an individual's alcohol use (59, 60). There is a potential heightened importance of social networks among stigmatized populations, such as black South African MSM (61). Therefore, a comprehensive understanding of hazardous drinking among black South African MSM should include an assessment of how they are influenced by psychosocial factors and social networks characteristics. The public health implications of potential findings could be particularly significant given the lack of other outlets through which to target them.

One potentially detrimental effect of drug and alcohol use is sexual risk behavior. Sexual risk behavior is especially important to investigate among populations with high rates of HIV (62), such as black South African MSM (9). HIV prevalence among the sample used for the empirical

analyses in this dissertation is 30% (63). While alcohol use has often been observed to be associated with sexual risk behavior, these findings have not always been consistent (64-66). Such inconsistencies have been observed among black South African MSM, in whom an initial study found that sexual risk behavior and alcohol use are common and that the two are associated (8), a finding, however, not replicated in a subsequent study (9). Findings regarding drug use and sexual risk behavior were also inconsistent.

One possible explanation for these inconsistencies is the unmeasured moderating effects of other psychosocial factors (67-79). Such factors impact the magnitude or even the direction of the effect of an exposure on an outcome. In a recent study conducted among black South African men who have sex with men (MSM), we found that reasons for drinking and intentions to engage in safer sex modified the relationship between substance use and HIV risk behavior, but that alcohol expectancies did not (77). Specifically, drinking led to sexual risk behavior among men who endorsed drinking to enhance social interaction but not among men who did not, while drug use led to increased sexual risk behavior among men who intended to engage in safer sex but not among men who did not (77). Indeed, the effects of substance use on sexual behavior are not necessarily homogeneous; they may be contingent on other factors. Thus, there is a need for research that assesses the relationship between substance use and sexual risk behavior among black South African MSM and explores the possibility of effect modification.

### **Dissertation Overview**

The overarching objective of this dissertation is to assess determinants of hazardous drinking and explore the relationship between substance use and HIV risk behavior among black South African MSM with a particular focus on the role of social networks. This will be achieved through: 1) a comprehensive, systematic review of the literature that describes the application of

social network analysis to the evaluation of alcohol use among adults (Aim 1); 2) an empirical assessment of determinants of hazardous drinking, including individual risk factors and social network characteristics (Aim 2); 3) an empirical assessment of whether substance use predicts HIV risk behavior during a defined sexual encounter, including whether the relationship between substance use and HIV risk behavior is modified by reasons for substance use, expectations about their effect on sexual behavior, and safe sex intentions (Aim 3). Alcohol use, particularly hazardous drinking, will be the focus of the analyses for this dissertation because of its high prevalence in the sample (62%) and its potentially deleterious consequences in this context of high HIV prevalence. However, other drug use will be described among the sample.

Furthermore, the item used to assess alcohol use prior to the defined sexual encounter that is the focus of the analyses in Aim 3 did not distinguish between alcohol or drug use; therefore, this dissertation will, at times, discuss substance use more generally, particularly in the context of that analysis and when reviewing literature that address both alcohol and drug use. Whenever possible, the terminology I use will reflect whether I am discussing alcohol use, drug use, or substance use (drug and alcohol use are not distinguished) This dissertation will use data drawn from the study, “HIV and Sexual Risk in African MSM in South African Townships” (R01-MH083557; PI: Sandfort, PhD) to achieve the empirical aims. This study used respondent-driven sampling (RDS) to recruit 480 black MSM in Tshwane, South Africa, thus providing information on these men’s ties to other MSM. A survey using previously validated measures to assess drug use, alcohol use, and sexual risk behavior was administered among these men.

This dissertation is comprised of five chapters. Following this introductory chapter, Chapter 2 presents a systematic review of existing literature relevant to Aim 1. This review aims to answer the following question: how have social network characteristics been shown to influence adults’

drinking behaviors, both in terms of characteristics of their network structures and characteristics of their network ties.

Chapter 3, which addresses Aim 2, is motivated by the fact that no study to date has identified risk factors for hazardous drinking among an African MSM population (40), including black South African MSM, despite the known burden of hazardous drinking among these men and its associated health risks. This chapter aims to describe alcohol use among black South African MSM and identify determinants that put them at risk for hazardous drinking. Psychosocial factors and social network characteristics will both be considered as potential determinants.

Chapter 4, which addresses Aim 3, is motivated by the fact that while alcohol use has often been observed to be associated with sexual risk behavior, these findings have not always been consistent (64-66). These inconsistencies have been observed among black South African MSM where an initial study found that men who regularly consumed alcohol were more than four times as likely to engage in unprotected anal intercourse as those who did not (8). However, a subsequent study among another sample of black South African MSM found no relation between alcohol use and sexual risk behavior (9). Information regarding the relationship between drug use and sexual risk behavior among black South African MSM has also not been consistent. This first study measured drug use but found no association with sexual risk behavior (8). In the second study, recent marijuana use was protective against HIV infection, although buying drugs or alcohol for a partner was a predictor of HIV infection (9). These discrepancies have not been explored. Possible explanations for these inconsistencies include the unmeasured moderating effects of other psychosocial factors (67-79). In a recent study conducted among black South African MSM, we found that reasons for drinking and intentions to engage in safer sex modified the relationship between substance use and HIV risk behavior, but that alcohol expectancies did

not (77). One limitation to our study, and others that have examined effect modification when looking at the relationship between substance use and sexual risk behavior (72, 74), is that they relied on general measures of substance use and sexual risk behavior over a specific time frame but without regard to their temporal overlap. For this chapter, I use data from a specific sexual event, where I can discern whether substances were used in close enough temporal proximity that they could influence sexual activity, in order to assess the direct effect between substance use and sexual risk behavior and then to assess effect modification of this relationship by alcohol expectancies, reasons for drinking and safer sex intentions.

Chapter 5 presents a summary of the findings of this dissertation along with a discussion of implications and future directions.



## References

1. Seeking J, Nattrass N. Class, race, and inequality in South Africa. Scottsville, South Africa: University of KwaZulu-Natal Press; 2005.
2. Altman D, Aggleton P, Williams M, Kong T, Reddy V, Harrad D, et al. Men who have sex with men: stigma and discrimination. *Lancet*. 2012;380(9839):439-45.
3. Rule SP, Mncwango B. Rights or wrongs? An exploration of moral values. In: Pillay U, Roberts B, Rule SP, editors. South African social attitudes : changing times, diverse voices. Cape Town, South Africa: Human Sciences Research Council; 2006.
4. Muraguri N, Temmerman M, Geibel S. A decade of research involving men who have sex with men in sub-Saharan Africa: current knowledge and future directions. *SAHARA J : journal of Social Aspects of HIV/AIDS Research Alliance / SAHARA* , Human Sciences Research Council. 2012;9(3):137-47.
5. Rich E. Overall research findings on levels of empowerment among LGBT people in Western Cape, South Africa. Cape Town, South Africa: Triangle Project; 2006.
6. Wells H. Levels of empowerment among lesbian, gay, bisexual and transgender [LGBT] people in Kwa-Zulu Natal, South Africa. Arcadia, South Africa: OUT LGBT Well-being; 2006.
7. Wells H, Polders L. Levels of empowerment among lesbian, gay, bisexual and transgender [LGBT] people in Gauteng, South Africa. Arcadia, South Africa: OUT LGBT Well-being; 2004.
8. Lane T, Shade SB, McIntyre J, Morin SF. Alcohol and sexual risk behavior among men who have sex with men in South african township communities. *AIDS and behavior*. 2008;12(4 Suppl):S78-85.
9. Lane T, Raymond HF, Dladla S, Raseth J, Struthers H, McFarland W, et al. High HIV prevalence among men who have sex with men in Soweto, South Africa: results from the Soweto Men's Study. *AIDS and behavior*. 2011;15(3):626-34.
10. Uhlemann AC, Knox J, Miller M, Hafer C, Vasquez G, Ryan M, et al. The environment as an unrecognized reservoir for community-associated methicillin resistant *Staphylococcus aureus* USA300: a case-control study. *PloS one*. 2011;6(7):e22407.
11. Sandfort TG, Nel J, Rich E, Reddy V, Yi H. HIV testing and self-reported HIV status in South African men who have sex with men: results from a community-based survey. *Sexually transmitted infections*. 2008;84(6):425-9.
12. Knox J, Reddy V, Kaighobadi F, Nel D, Sandfort T. Communicating HIV status in sexual interactions: assessing social cognitive constructs, situational factors, and individual characteristics among South African MSM. *AIDS and behavior*. 2013;17(1):350-9.
13. Baral S, Sifakis F, Cleghorn F, Beyrer C. Elevated risk for HIV infection among men who have sex with men in low- and middle-income countries 2000-2006: a systematic review. *PLoS medicine*. 2007;4(12):e339.
14. Latkin CA, Knowlton AR. Social network approaches to HIV prevention: Implications for community impact and sustainability. In: Trinidad-Carrillo M, Pequegnat W, editors. *Community interventions and AIDS*. New York: Oxford University Press; 2005. p. 105-29.
15. Brissette I, Cohen S, Seeman TE. Measuring social integration and social networks. In: Cohen S, Underwood LG, Gottlieb BH, editors. *Social support measurement and intervention*. New York: Oxford University Press; 2000. p. 53-85.

16. Christakis NA, Fowler JH. *Connected. The surprising power of networks and how they shape our lives.* New York: Little, Brown; 2009.
17. Latkin C, Donnell D, Celentano DD, Aramrattna A, Liu TY, Vongchak T, et al. Relationships between social norms, social network characteristics, and HIV risk behaviors in Thailand and the United States. *Health Psychol.* 2009;28(3):323-9.
18. Luke DA, Harris JK. Network analysis in public health: History, methods, and applications. *Annu Rev Publ Health.* 2007;28:69-93.
19. Friedman SR, Bolyard M, Mateu-Gelabert P, Goltzman P, Pawlowicz MP, Singh DZ, et al. Some data-driven reflections on priorities in AIDS network research. *Aids Behav.* 2007;11(5):641-51.
20. Valente TW, Fosados R. Diffusion of innovations and network segmentation: The part played by people in promoting health. *Sexually Transmitted Diseases.* 2006;33(7):S23-S31.
21. Rabie F, Lesch E. 'I am like a woman': constructions of sexuality among gay men in a low-income South African community. *Culture, Health & Sexuality.* 2009;11(7):717-29.
22. Smith KP, Christakis NA. Social networks and health. *Annual Review of Sociology.* 2008;34:405-29.
23. Israel BA. Social networks and health-status - Linking theory, research, and practice. *Patient Counselling and Health Education.* 1982;4(2):65-79.
24. Umberson D, Montez JK. Social relationships and health: A flashpoint for health policy. *J Health Soc Behav.* 2010;51:S54-S66.
25. Johnson BT, Redding CA, DiClemente RJ, Mustanski BS, Dodge B, Sheeran P, et al. A network-individual-resource model for HIV prevention. *Aids Behav.* 2010;14:S204-S21.
26. Berkman LF, Glass T. Social integration, social networks, social support, and health. In: Berkman LF, Kawachi I, editors. *Social epidemiology.* New York: Oxford University Press; 2000. p. 137-73.
27. Kottiri BJ, Friedman SR, Neaigus A, Curtis R, Des Jarlais DC. Risk networks and racial/ethnic differences in the prevalence of HIV infection among injection drug users. *Journal of Acquired Immune Deficiency Syndromes.* 2002;30(1):95-104.
28. Friedman SR, Aral S. Social networks, risk-potential networks, health, and disease. *Journal of Urban Health.* 2001;78(3):411-8.
29. Friedman SR, Neaigus A, Jose B, Curtis R, Goldstein M, Idefonso G, et al. Sociometric risk networks and risk for HIV infection. *Am J Public Health.* 1997;87(8):1289-96.
30. Simons JS, Neal DJ, Gaher RM. Risk for marijuana-related problems among college students: An application of zero-inflated negative binomial regression. *Am J Drug Alcohol Ab.* 2006;32(1):41-53.
31. Neighbors C, Lee CM, Lewis MA, Fossos N, Larimer ME. Are social norms the best predictor of outcomes among heavy-drinking college students? *J Stud Alcohol Drugs.* 2007;68(4):556-65.
32. Prentice DA, Miller DT. Pluralistic ignorance and alcohol-use on campus - Some consequences of misperceiving the social norm. *J Pers Soc Psychol.* 1993;64(2):243-56.
33. Buttross LS, Kastner JW. A brief review of adolescents and tobacco: What we know and don't know. *American Journal of the Medical Sciences.* 2003;326(4):235-7.
34. Smith AMA, Grierson J, Wain D, Pitts M, Pattison P. Associations between the sexual behaviour of men who have sex with men and the structure and composition of their social networks. *Sex Transm Infect.* 2004;80(6):455-8.

35. Choi KH, Ning Z, Gregorich SE, Pan QC. The influence of social and sexual networks in the spread of HIV and syphilis among men who have sex with men in Shanghai, China. *Journal of Acquired Immune Deficiency Syndromes*. 2007;45(1):77-84.
36. Laumann EO, Youm Y. Racial/ethnic group differences in the prevalence of sexually transmitted diseases in the United States: A network explanation. *Sexually Transmitted Diseases*. 1999;26(5):250-61.
37. Youm Y, Laumann EO. Social network effects on the transmission of sexually transmitted diseases. *Sexually Transmitted Diseases*. 2002;29(11):689-97.
38. Kelly JA, Amirkhanian YA, Seal DW, Galletly CM, DiFranceisco W, Glasman LR, et al. Levels and predictors of sexual HIV risk in social networks of men who have sex with men in the Midwest. *Aids Educ Prev*. 2010;22(6):483-95.
39. Doherty IA, Padian NS, Marlow C, Aral SO. Determinants and consequences of sexual networks as they affect the spread of sexually transmitted infections. *Journal of Infectious Diseases*. 2005;191:S42-S54.
40. Sandfort T, Knox J, Alcala C, El-Bassel N, Kuo I, Smith L. Substance use and HIV risk among men who have sex with men in Africa: A systematic review. *J Acquir Immune Defic Syndr*. In Press.
41. Sandfort TG, de Graaf R, Bijl RV, Schnabel P. Same-sex sexual behavior and psychiatric disorders: findings from the Netherlands Mental Health Survey and Incidence Study (NEMESIS). *Arch Gen Psychiatry*. 2001;58(1):85-91.
42. Sandfort TG, de Graaf R, Ten Have M, Ransome Y, Schnabel P. Same-sex sexuality and psychiatric disorders in the second Netherlands Mental Health Survey and Incidence Study (NEMESIS-2). *LGBT Health*. 2014;1(4):292-301.
43. Stall R, Paul JP, Greenwood G, Pollack LM, Bein E, Crosby GM, et al. Alcohol use, drug use and alcohol-related problems among men who have sex with men: the Urban Men's Health Study. *Addiction (Abingdon, England)*. 2001;96(11):1589-601.
44. McKirnan DJ, Peterson PL. Psychosocial and cultural factors in alcohol and drug abuse: an analysis of a homosexual community. *Addictive behaviors*. 1989;14(5):555-63.
45. McKirnan DJ, Peterson PL. Alcohol and drug use among homosexual men and women: epidemiology and population characteristics. *Addictive behaviors*. 1989;14(5):545-53.
46. Stall R, Mills TC, Williamson J, Hart T, Greenwood G, Paul J, et al. Association of co-occurring psychosocial health problems and increased vulnerability to HIV/AIDS among urban men who have sex with men. *Am J Public Health*. 2003;93(6):939-42.
47. Jie W, Ciyong L, Xueqing D, Hui W, Lingyao H. A syndemic of psychosocial problems places the MSM (men who have sex with men) population at greater risk of HIV infection. *PloS one*. 2012;7(3):e32312.
48. Rosario M, Schrimshaw EW, Hunter J. A model of sexual risk behaviors among young gay and bisexual men: longitudinal associations of mental health, substance abuse, sexual abuse, and the coming-out process. *AIDS education and prevention : official publication of the International Society for AIDS Education*. 2006;18(5):444-60.
49. Wang J, Hausermann M, Ajdacic-Gross V, Aggleton P, Weiss MG. High prevalence of mental disorders and comorbidity in the Geneva Gay Men's Health Study. *Social psychiatry and psychiatric epidemiology*. 2007;42(5):414-20.
50. Niang CI, Tapsoba P, Weiss E, Diagne M, Niang Y, Moreau AM, et al. 'It's raining stones': stigma, violence and HIV vulnerability among men who have sex with men in Dakar, Senegal. *Cult Health Sex*. 2003;5(6):499-512.

51. van Griensven F. Men who have sex with men and their HIV epidemics in Africa. *AIDS*. 2007;21(10):1361-2 10.097/QAD.0b013e328017f868.
52. van Griensven F, Sanders EJ. Understanding HIV risks among men who have sex with men in Africa. *Sexually Transmitted Diseases*. 2008;35(4):355-6.
53. Smith AD, Tapsoba P, Peshu N, Sanders EJ, Jaffe HW. Men who have sex with men and HIV/AIDS in sub-Saharan Africa. *Lancet*. 2009;374(9687):416-22.
54. Adam PCG, de Wit JBE, Toskin I, Mathers BM, Nashkoev M, Zablotska I, et al. Estimating levels of HIV testing, HIV prevention coverage, HIV knowledge, and condom use among men who have sex with men (MSM) in low-income and middle-income countries. *J Acquir Immune Defic Syndr*. 2009;52:S143-S51.
55. Muraguri N, Temmerman M, Geibel S. A decade of research involving men who have sex with men in sub-Saharan Africa: current knowledge and future directions. *SAHARA J*. 2012;9(3):137-47.
56. Smith KP, Christakis NA. Social networks and health. *Annu Rev Sociol*. 2008;34:405-29.
57. Valente TW. Social network influences on adolescent substance use: an introduction. *Connections*. 2003;25(2):11-6.
58. Alexander C, Piazza M, Mekos D, Valente T. Peers, schools, and adolescent cigarette smoking. *The Journal of adolescent health : official publication of the Society for Adolescent Medicine*. 2001;29(1):22-30.
59. Windle M. Parental, sibling, and peer influences on adolescent substance use and alcohol problems. *Appl Dev Sci*. 2000;4:98-110.
60. Gaughan M. Predisposition and pressure: mutual influence and adolescent drunkenness. *Connections*. 2003;25(2):17-31.
61. Latkin CA, Davey-Rothwell MA, Knowlton AR, Alexander KA, Williams CT, Boodram B. Social network approaches to recruitment, HIV prevention, medical care, and medication adherence. *J Acquir Immune Defic Syndr*. 2013;63 Suppl 1:S54-8.
62. Kalichman SC, Simbayi LC, Kaufman M, Cain D, Jooste S. Alcohol use and sexual risks for HIV/AIDS in sub-Saharan Africa: Systematic review of empirical findings. *Prev Sci*. 2007;8(2):141-51.
63. Sandfort TG, Lane T, Dolezal C, Reddy V. Gender expression and risk of HIV infection among black South African men who have sex with men. *AIDS and behavior*. 2015;19(12):2270-9.
64. Rehm J, Shield KD, Joharchi N, Shuper PA. Alcohol consumption and the intention to engage in unprotected sex: systematic review and meta-analysis of experimental studies. *Addiction (Abingdon, England)*. 2012;107(1):51-9.
65. Pithey A, Parry C. Descriptive systematic review of Sub-Saharan African studies on the association between alcohol use and HIV infection. *SAHARA J : journal of Social Aspects of HIV/AIDS Research Alliance / SAHARA , Human Sciences Research Council*. 2009;6(4):155-69.
66. Stall R, Purcell DW. Intertwining epidemics: a review of research on substance use among men who have sex with men and its connection to the AIDS epidemic. *AIDS and behavior*. 2000;4(2):181-92.
67. Woolf-King SE, Maisto SA. Alcohol use and high-risk sexual behavior in Sub-Saharan Africa: a narrative review. *Archives of sexual behavior*. 2011;40(1):17-42.
68. Weinhardt LS, Carey MP. Does alcohol lead to sexual risk behavior? Findings from event-level research. *Annual review of sex research*. 2000;11:125-57.

69. Fromme K, D'Amico EJ, Katz EC. Intoxicated sexual risk taking: an expectancy or cognitive impairment explanation? *Journal of studies on alcohol*. 1999;60(1):54-63.
70. George WH, Stoner SA, Norris J, Lopez PA, Lehman GL. Alcohol expectancies and sexuality: a self-fulfilling prophecy analysis of dyadic perceptions and behavior. *Journal of Studies on Alcohol*. 2000;61:168-76.
71. George WH, Stoner SA. Understanding acute alcohol effects on sexual behavior. *Annual review of sex research*. 2000;11:92-124.
72. McKirnan DJ, Vanable PA, Ostrow DG, Hope B. Expectancies of sexual "escape" and sexual risk among drug and alcohol-involved gay and bisexual men. *Journal of substance abuse*. 2001;13(1-2):137-54.
73. Dermen KH, Cooper ML, Agocha VB. Sex-related alcohol expectancies as moderators of the relationship between alcohol use and risky sex in adolescents. *Journal of studies on alcohol*. 1998;59(1):71-7.
74. Bryan AD, Ray LA, Cooper ML. Alcohol use and protective sexual behaviors among high-risk adolescents. *J Stud Alcohol Drugs*. 2007;68(3):327-35.
75. Newcomb ME, Clerkin EM, Mustanski B. Sensation seeking moderates the effects of alcohol and drug use prior to sex on sexual risk in young men who have sex with men. *AIDS and behavior*. 2011;15(3):565-75.
76. Mustanski B. Moderating effects of age on the alcohol and sexual risk taking association: an online daily diary study of men who have sex with men. *AIDS and behavior*. 2008;12(1):118-26.
77. Knox J, Reddy V, Lane T, Hasin D, Sandfort T. Substance use and sexual risk behavior among black South African men who have sex with men: the moderating effects of reasons for drinking and safer sex intentions. *AIDS and behavior*. In Press.
78. Gordon CM, Carey MP, Carey KB. Effects of a drinking event on behavioral skills and condom attitudes in men: implications for HIV risk from a controlled experiment. *Health Psychol*. 1997;16(5):490-5.
79. Morojele NK, Kachieng'a MA, Mokoko E, Nkoko MA, Parry CD, Nkowane AM, et al. Alcohol use and sexual behaviour among risky drinkers and bar and shebeen patrons in Gauteng province, South Africa. *Social science & medicine*. 2006;62(1):217-27.

## **Chapter 2 Social Network Analysis to Examine Alcohol Use among Adults: A Systematic Review**

### **Introduction**

Social networks, sets of individuals linked together by one or more types of relations. Social networks can be formed around shared activities (e.g. sports teammates) or shared environments (e.g. schoolmates or neighbors). The study of social networks presumes that actors (or nodes) and actions are interdependent and that information and influence flows along the ties formed between people (1). Social networks and our increasing capacities to analyze them have made them of growing interest to researchers in disciplines ranging from anthropology to economics (2).

Social network analysis, a growing and heterogeneous field (3), is the term applied to the set of theories, methods and techniques used to investigate how social interactions between individuals influence certain outcomes (2). A fundamental concept in social network analysis is that it incorporates information about relationships between pairs of individuals (i.e., network members) (2). Data on social networks can be collected using two primary approaches (2). The first approach, egocentric networks, collect information about a person's (i.e. an ego) social network (their alters) only from the ego's perspective (2). Egocentric network data are limited to perceptions of those surveyed (i.e. the ego's perceptions of alters' behaviors or of ties between alters). The second approach, sociometric networks, provide a more comprehensive assessment of a social network by interviewing multiple members of the network (2). Sociometric techniques are most often used when studying discrete social networks whose boundaries can be easily defined, such as schools or office groups. While sociometric data are more laborious and challenging to collect, they have greater analytic possibilities because they allow one to measure

the actual behavior of alters, rather than just the ego's perception of their behavior. Further, sociometric data provide a global view of a social network and its structure, including multiple members' perspectives. Table 2.1 provides a list of many of the terms used in social network analyses and their definitions.

As with other phenomena, social networks matter to health (1). Social networks provide a structure through which communicable diseases can be transmitted. Social networks also allow for people to influence each other by sharing information, expressing support, and creating social norms (i.e. they are the context in which people display normative behavior amongst each other). Social networks have been shown to play a major role in influencing many health-related behaviors, both healthy behaviors, such as smoking cessation or HIV prevention (1, 4-7) and unhealthy behaviors, such as drug use and HIV risk (8-10). Specific interventions have also been developed that utilize social networks to promote behavior change (11).

Social networks analysis has shown that social networks affect the health of their members in two main ways. One way is that characteristics of the social network structure influence health outcomes. Using this approach, the presence of social network ties in themselves (e.g. being connected versus isolated) are considered as determinants of health (12-14). Also using this approach, social network ties provide conduits along which a virus or information can spread (15-21). Analysis of the linkages among members of a social network often involves visualizing social structures (i.e. generating maps of persons and how they are connected), which allows for the identification of individuals that are critical for transmission based on their position within a network. A second way that social networks have been shown to influence the health of their members is that the characteristics of alters in one's social network provide a context for the ego's behavior and norms (22-25). Using this method, the characteristics of nodes themselves are

explored to assess their relationships to the characteristics of other nodes (e.g., do the substance use patterns of one's close friends influence an individual's substance use). While we distinguish between these two approaches, they are often inter-related; as for example, one's degree of connectedness to a specific social network has been found to be positively associated with one's likelihood of reflecting the normative behavior of that group (12). While it may seem obvious that understanding the structure and characteristics of social networks is relevant to communicable diseases, such as the spread of viruses and bacteria, social networks structure and characteristics have also been linked to non-communicable diseases (26, 27), even implausible ones, such as acne, height and headaches (28), and health behaviors, such as alcohol use (29-36). Alcohol use and heavy drinking constitute a major public health problem (37), contributing to morbidity (38) and mortality (39) worldwide. Alcohol consumption both shapes (i.e. people often form friendships while drinking) and is shaped by the presence of personal social network ties (i.e. one's connectedness to specific social networks may be expressed through shared activities like drinking). Social networks may have grown or been maintained at drinking venues or events that involved drinking, and in such networks drinking behavior may be subject to social influence. Thus, an individual's social network members' drinking behaviors may provide a crucial context for individual decisions on how much and how often to drink (40).

Much of the empirical research that has used social network analysis to examine alcohol use has been conducted among adolescent populations (29-36, 41, 42). As evidence, a recent systematic review on the use of social network analyses to understand risky behaviors focused solely on empirical research conducted among adolescents, using the many papers that used data from the National Longitudinal Study of Adolescent to Adult Health (Add Health) (43). Taken together, these studies have shown that social network characteristics are important determinants of



adolescent drinking behaviors, both in terms of characteristics of their network structures and characteristics of their network ties. A similar review has not been conducted among adult populations, despite numerous empirical social network studies examining alcohol use among adults, especially young adults. This is a gap in our understanding as social network dynamics are different among adults than adolescents (44). Furthermore, alcohol consumption is a different phenomenon among adults as it can be consumed legally, thus the influence of social network dynamics might also be different.

The current paper aims to address this gap by answering the following question: how have social network characteristics been shown to influence adults' drinking behaviors, both in terms of characteristics of their network structures and characteristics of their network ties? In order to answer this question, I systematically identified and described empirical studies that used social network analysis to evaluate alcohol use among adults (persons who are 18 years and older). This review will not be restricted to studies conducted among samples of MSM because there would be too few. This review is limited to studies that collected sociometric network data in order to focus on robust applications of social network analysis. I then synthesized the findings of identified studies that statistically measured the influences of social networks on alcohol use among adults. Because the methodologies used in social network analysis studies are heterogeneous, they do not lend themselves to meta-analysis. Therefore, a narrative synthesis of the studies was conducted. Understanding the contribution of social interactions to alcohol use will help to inform public health professionals on determinants of risk, as well as appropriate prevention and treatment strategies.

## **Methods**

This review was informed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement and the PRISMA checklist (45, 46) is shown in Table A1.1.

### *Data Sources and Literature Search*

A literature search of 4 databases (PubMed/MEDLINE, EMBASE, PsycINFO and Web of Science, Sociological) was conducted in June 2017 to identify studies that used sociocentric social network analysis to evaluate the effects of social network characteristics on alcohol use. Keyword search strategies and terms varied based on the database (to account for distinct indexing criteria) and are described in detail in Table A1.2. To identify additional studies not found in the literature search, the reference lists of relevant reviews and included articles were reviewed. The literature search was conducted with guidance from an Education and Curriculum Librarian who serves as the Coordinator for Systematic Review Services at the New York University School of Medicine.

### *Inclusion and Exclusion Criteria*

Duplicates were removed and screening of retrieved articles by title and abstract was conducted by two independent reviewers using Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia. Available at [www.covidence.org](http://www.covidence.org)). Final inclusion was determined by two independent reviewers screening the full-text of potentially eligible articles using the following criteria. Studies were eligible to be included in the review if they were (1) published in a peer-reviewed journal, (2) written in English, (3) conducted in human populations, (4) utilized a social network analysis design for which sociometric data were collected (i.e., data linking participants were measured or inferred (e.g., known roommates were considered ties) and

data were collected among alters) and network visualizations were generated or network measures were calculated based on this data, (5) evaluated alcohol use as an outcome, and 6) included a majority of participants that were adults (18 years or older). There were no date restrictions in the inclusion criteria; studies from any year were potentially eligible to enter the review if they met the other inclusion criteria. In addition to the inclusion criteria, studies were excluded if (1) transmission was assessed using simulated networks, (2) social contact pattern data were collected but were not used in the context of a social network analysis, (3) the study described qualitative research or was a case study.

### *Quality Assessment*

A 12-item quality assessment tool was used for the purposes of this review (Table A1.3) to evaluate study relevance and methodology. The tool was developed using modified sets of criteria from other quality assessment tools for assessing observational studies (47), network studies (48), and qualitative research studies (49). Articles with a quality score of less than 70% were excluded from the review because they did not have appropriate or sufficient data or reporting quality; although all articles identified met the criteria for inclusion.

### *Data Extraction and Synthesis*

A data extraction form was developed to extract information on study objectives, study design and sampling approach, data collection method, setting and target population, participants, relational data collection (used to link study participants for the social network analysis), outcome measurement, social network analysis methods used to analyze the data and calculated measures, statistical analyses used (as relevant to social network analysis), and key findings.

## Results

### *Identifying empirical studies*

The database search yielded 5,155 records for screening (4,748 after removing duplicates) and an additional 35 were included for screening based on reference list review. The full text of 139 articles was reviewed to determine eligibility and 18 articles were judged potentially eligible and further assessed for quality and relevance (Table A1.4); ultimately, all 18 articles were included in the review (Figure 2.1) (50-67).

### *Describing included studies*

Among the included studies, 15 were conducted in the United States (50-54, 56-61, 63, 65-67) and 3 were conducted in different European countries (55, 62, 64). The majority of studies (13) were conducted among university students (51-57, 59, 61-65), with 5 studies conducted in community settings (50, 58, 60, 66, 67). Half (9) of the studies were cross-sectional (51-53, 58, 59, 62-64, 67) and half (9) were longitudinal (50, 54-57, 60, 61, 65, 66). Characteristics of the included studies are summarized in Table 2.2. Sample selection procedures included the use of respondent-driven sampling (67), recruitment of entire peer groups (64), and the collection of complete sociometric social networks (56, 62, 65). Sample sizes ranged from 34 (65) to 15,197 (56). Mean age ranged from 18 years to 51 years. Proportion of male participants ranged from 25% (65) to 100% (55). Details of the studies, including objective, study period and design, setting, participant characteristics, data sources, social network measures, analytic methods, and major findings are presented in Table 2.3.

The objectives of the included studies were heterogeneous. Eight of the studies assessed the influence of characteristics of network structure (e.g., network density [the total number of

observed ties divided by the maximum number of possible ties] or betweenness centrality [the number of pairs of nodes a given node connects that would otherwise not be connected]) as exposures (51, 52, 55, 56, 58, 62, 65, 66). Twelve of the studies assessed characteristics of network ties (e.g. ties' weekly alcohol consumption or ties' beliefs about alcohol) as exposures (50, 52-54, 57, 59-61, 63, 64, 66, 67) (with 2 studies assessing both) (52, 66). Specific social network measures discussed in this review are listed and defined in Table 2.1.

The methods used in the included studies were also heterogeneous. All of the studies measured some form of alcohol consumption over a specific time period as the outcome, with some using as few as a single item and others measuring multiple forms of consumption using previously validated scales. Outcome measures included frequency of alcohol consumption, quantity of alcohol consumption, and frequency of binge drinking. One naturalistic observational study relied on observed counts of alcoholic drinks consumed (64) while the other 17 studies relied on self-reported data (50-63, 65-67), including one that compared perceived levels of alcohol consumption by peers to self-reported alcohol consumption by participants (63). There was also heterogeneity in the statistical analyses used to assess social network characteristics, although the majority used some form of regression modeling. Many of the longitudinal studies used Generalized Estimating Equations (GEE) to account for repeated measures. Overall, the methodologies described by the included studies were rigorous in terms of the data collected and the methods used to analyze it, as evidenced by all of the full-text studies that were identified exceeding the quality assessment threshold for inclusion in the review.

### *Synthesis of the findings*

Despite the heterogeneity in social network measures and analyses, all of the included studies observed an association of a social network characteristic with an alcohol-related outcome.

Studies that considered characteristics of network ties (e.g. ties' weekly alcohol consumption or ties' beliefs about alcohol) as exposures (50, 52-54, 57, 59-61, 63, 64, 66, 67) all found that the alcohol consumption of a participant's peers was associated with the participant's alcohol consumption. In a naturalistic observational study, peer group alcohol consumption was the strongest predictor of participants' alcohol consumption (64). The studies that used longitudinal data to explore peer effects attempted to assess whether the observed association between peers' and participants' alcohol consumption (i.e. homophily, the tendency for nodes with similar characteristics to be connected) was a result of selection (i.e. individuals choose to befriend others who are like them), confounding (peers are similar because of a shared environment) or induction (friends influence each other to become more similar). Andrews et al. found support for selection for binge drinking and induction for quantity of alcohol consumption (50).

Rosenquist et al. used data from the Framingham Heart Study to show how peer effects diminished across degrees of separation (66). The authors felt their findings provided more support for induction because the directionality of friendship nominations mattered and they controlled for participants' previous alcohol consumption. Ott et al. showed how a novel Bayesian comparative calibration model could be used to improve estimates of self-reported consumption despite the peer-reports that it relied on being overestimates of individuals' alcohol consumption (63).

Studies that assessed the influence of characteristics of network structure as exposures (51, 52, 55, 56, 58, 62, 65, 66) also all observed an association of a social network characteristic with an

alcohol-related outcome. Among young men who have sex with men in a community setting, Janulis et al. observed that transitivity (the extent to which the relation between two nodes in a network that are connected by an edge is transitive, or put more plainly, that friends of my friends are my friends) positively influenced an ego's frequency of alcohol use (58). Among university students in Belgium, Lorant et al. found that centrality was positively associated with binge drinking (62). Barnett achieved the same finding among university students in the US (51). Among university students in Germany, Giese et al. observed that reciprocation of friendship only mattered with regards to participants' frequency of drinking but not the quantity of alcohol they consumed (55). Using data from the young adults who participated in Wave 3 of the Add Health study, Hahm et al. observed that centrality was associated with binge drinking, although, in general, the strength of social network effects had diminished from adolescence into adulthood regardless of how robust the impact was during adolescence (56). This is not to say that social network effects do not matter during adulthood as multiple studies observed clustering of alcohol use and alcohol-related problems (52, 66). Studies that used longitudinal data also observed that social networks became more homophilous over time (65, 66).

## **Discussion**

In this review, 18 studies were identified and evaluated to answer the following question: how have social network characteristics been shown to influence adults' drinking behaviors, both in terms of characteristics of their network structures and characteristics of their network ties?

Overall, these studies found that characteristics of one's peers as well as social network structure influenced egos' alcohol consumption in a variety of ways and across settings. Studies that explored the homophily of social networks observed that members of a shared social network became more alike over time in terms of drinking (65, 66) and that selection and induction were

both likely contributing factors (50, 66). These results suggest that social network effects, including both peer characteristics and social structure, influence alcohol consumption among adults.

There was a remarkable amount of heterogeneity in the ways that the included studies approached this topic, in terms of how social network characteristics were measured, visualized, and analyzed. There was also considerable heterogeneity in the studies in regards not related to social networks; for example, in the various ways alcohol use was measured. One outstanding fact is that a high proportion (72%) of studies were conducted in university settings. This is likely because it is easier to collect sociometric network data in institutionalized settings. Further, young adult populations might be more frequently studied because peer dynamics are expected to be stronger in young adulthood (i.e. an extension of adolescence) than in later adulthood (56). This points to the need to collect sociometric social network data among older adults where far less is understood about social network effects. In general, though, the use of social network analysis helped to capture, describe, and account for the complex flow of behaviors, information, attitudes and norms among individuals and the relationships that they form. Additionally, the application of network visualization and advanced statistical tests strengthened the inferences drawn.

Because of the heterogeneity in assessment strategies, the limitations of self-report, and the lack of generalizability within studies, it is difficult to make generalizations about the effects of social network characteristics on alcohol consumption among adults. Social network characteristics seem to influence alcohol consumption but they seem to work in a variety of ways. There also remains much to be explored about whether the homophily that has been observed among networks of adults is due to the proclivity to befriend people similar to oneself, the effects of



shared environments, or that this truly represents the spread of alcohol consumption. This is a particularly salient issue when researching alcohol consumption (as opposed to other health behaviors) because drinking is often a shared social activity.

This review and the study results have several limitations. First, only 18 studies were identified and deemed eligible to be included based on relevance and quality. This is likely because the use of social network analysis to study alcohol use among adults is much more challenging than studying peer effects among adolescents, where social network data are easier to collect and peer effects seemingly more salient. Articles may have been missed because the use of social network methods was not indicated in the title or abstract and thus they would not have been identified during the literature search. However, for that reason, a broad search was conducted and ultimately 4,780 articles were screened based on title and abstract. Similarly, many studies have used egocentric approaches to conduct social network analysis but these were excluded because they did not utilize sociometric data; such studies would have been identified by my search criteria but were excluded from the review. Second, the results of social network analysis studies are context specific and insights are likely to vary based on setting and the exposures and the outcomes that were measured. Attempts to synthesize across the included studies were difficult given their heterogeneity. Even findings within studies varied by whether the researchers were looking at frequency of alcohol consumption, quantity of alcohol consumption, or outcomes related to binge drinking. Further research is needed to implement some level of standardization across studies and to assess the replicability of findings in different settings. While there was heterogeneity with regards to study methodologies, there was much less with regard to types of study settings. Namely, 15 of the 18 studies were conducted among college students. Results showing the importance of peer effects on alcohol consumption across different college settings

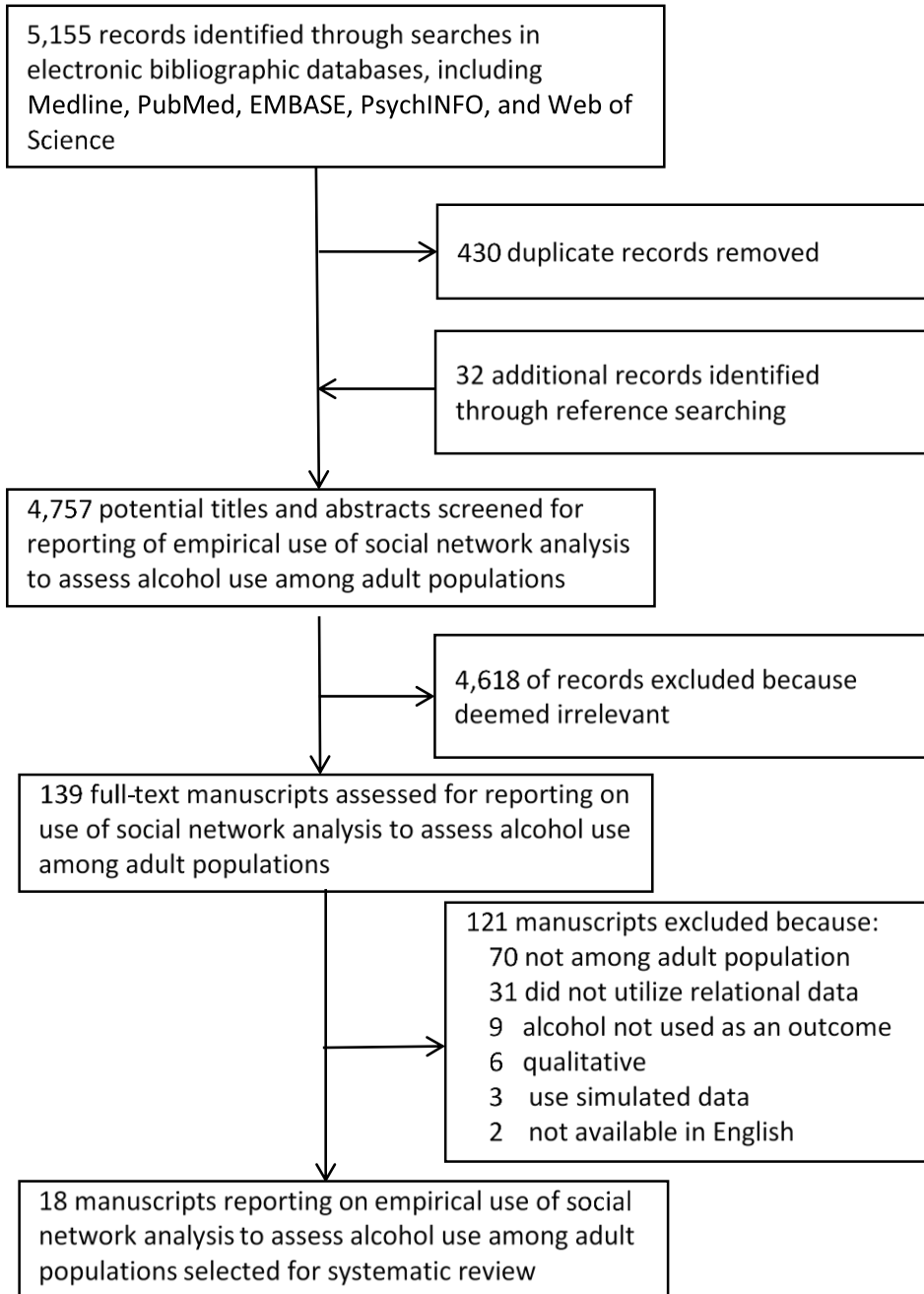
speaks to the importance of peer effects during this developmental period, although they should not be assumed among older adults for whom social network dynamics differ (65). Finally, implementing social network analysis can be resource intensive, requiring extensive data collection and/or data mining. Network methods are still relatively novel in the context of substance use epidemiology, with 72% of the included papers published since 2010, and expertise and training are needed in order to conduct social network studies, analyze social network data, and interpret the results correctly.

*Implications for research and intervention*

Despite the limitations, this review demonstrated the utility of social network analysis for studying alcohol consumption among adult populations and its adaptability to various settings. To date, relatively few studies have used social network analysis to study alcohol consumption among adult populations, suggesting that these approaches are underutilized. However, social networks appear to matter when alcohol outcomes are considered, and social network analysis remains a powerful tool with the potential to explore their effects. These findings can be used to inform researchers, public health professionals, and policy makers about structures of networks, their role in the spread of alcohol use, and the potential for interventions that utilize these pre-existing networks to help reduce the burden of harmful alcohol consumption.

## Figures

Figure 2.1. Flow diagram of search strategy and selection process



## Tables

Table 2.1. Definitions of social network analysis terms and measures used in the reviewed articles

<b>Term/Measure</b>	<b>Definition</b>
Structure	Networked sets of nodes and the ties that connect them
Nodes	Represent distinct network members (e.g., study participants, places of social aggregation)
Ties	Represent relationships that link nodes within a network
Characteristic	A feature or quality belonging to a node
Network density	The total number of observed ties divided by the maximum number of possible ties
Degree centrality	The number of nodes that a given node can encounter within one step (i.e., they are directly connected)
Normalized group degree centrality	Number of nodes outside a given subgroup that are connected to nodes within the subgroup, normalized by dividing the group degree by the number of nodes outside the group
Betweenness centrality	The number of pairs of nodes a given node connects that would otherwise not be connected
Closeness centrality	How close a node is to all other nodes (directly and indirectly) as a function of geodesic distance
Reach centrality	The number of nodes a given node can encounter within x steps
Homophily	Tendency for nodes with similar characteristics to be connected
Transitivity	The extent to which the relation that relates two nodes in a network that are connected by an edge is transitive

Table 2.2. Summary of characteristics of n=18 articles included in the systematic review

<b>Characteristic</b>	<b>n (%)</b>
<b>Country</b>	
US	15 (83)
Europe (Germany, Belgium, Netherlands)	3 (17)
<b>Setting</b>	
College	13 (72)
Community	5 (28)

Table 2.3. Summary of social network analysis studies with alcohol as an outcome among adult populations

Study	Objective	Study details <sup>1</sup>	Study design	Data sources	Social network measure(s)	Statistical analyses <sup>2</sup>	Major findings related to the social network analyses
Andrews et al. (2002)	Examine if young adult peers are similar to each other in their use of substances and, if so, if the similarity is due in part to the socialization or influence of peers. Examine if similarity and influence vary as a function of the gender of the target participant or their peer.	US 294 young adults and both a same- and an opposite-gender best friend from moderate-sized northwestern urban areas from 1993-1996 21.8 years = mean age (at baseline) 37% male	Longitudinal	Interview with target participant and interview with a same- and an opposite-gender friend from among their 5-closest same- and opposite-gender friends	Peers' weekly consumption of alcohol and peers' frequency of binge drinking' in the past year	Linear regression with GEE	Observed a concurrent and prospective relation in binge drinking between the participant's male and female friends and the participant, suggesting peer socialization as one process explaining the similarity between peers in binge drinking. Observed a concurrent, but not a prospective, relation between (a) both same- and opposite-gender friend's alcohol use and the alcohol use of the participant, suggesting selection (influence of peers) as one process explaining the similarity between peers in alcohol use.
Barnett et al. (2014a)	Investigate five different social network characteristics (indegree centrality, betweenness centrality, outdegree, indegree reciprocity, and outdegree reciprocity) for alcohol use and alcohol-related problems in a college residence network	US 129 students living on a college campus in the NE 48% male	Cross-sectional	Interview with SNQ of up to 10 people who lived in the residence hall	Indegree centrality, betweenness centrality, outdegree, indegree reciprocity, outdegree reciprocity	Simultaneous autoregressive (SAR) autocorrelation models	Two network characteristics were significantly associated with alcohol use and a third showed an association for women only. Outdegree was significantly positively related to number of heavy drinking days. Betweenness centrality was significantly positively related to number of alcohol problems. Betweenness centrality and indegree reciprocity were significantly associated with greater alcohol problems for women.

Study	Objective	Study details <sup>1</sup>	Study design	Data sources	Social network measure(s)	Statistical analyses <sup>2</sup>	Major findings related to the social network analyses
Barnett et al. (2014b)	Use a college residence hall peer network to examine associations between peer behaviors and alcohol use, marijuana use, and exercise behavior	US 129 students living on a college campus in the NE 48% male	Cross-sectional	Interview with SNQ of up to 10 people who lived in the residence hall	Cluster identification based on betweenness Weekly volume of alcohol consumed by direct ties	Network autocorrelation models	Community detection cluster analysis used only directed ties to detect subcommunities of individuals, and the comparison of those groups established that they differed significantly on demographic, activity, and behavior profiles, including alcohol use and alcohol-related problems. The drinking volume of nominated peers was significantly positively associated with participant drinking volume.
Duncan et al. (2005)	Explore how peers affect drug use and problematic sexual behavior among college students.	US 714 incoming students at a large, academically strong state university in 2002. 39% male	Cross-sectional	Interview (CIRP Entering Student annual survey) linked to interview of randomly assigned college roommate	Dichotomous high school binge drinking among roommate	Fixed-effects regression in which peer effect estimates are based only on within-preference-cell variability	Males who reported binge drinking in high school drink much more in college if assigned a roommate who also binge drank in high school than if assigned a nonbinge-drinking roommate. Students who did not binge drink in high school do not appear to be affected by their roommates' high school behavior.
Eisenberg et al. (2014)	Use the natural experiment of assigned college roommates to estimate peer effects for substance use and other risky behaviors.	US 1641 first-year college students at 2 large and competitive universities: one public, one private from 2009-2010 18.4 years = mean age (at baseline) 46% male	Longitudinal	On-line interview linked to randomly assigned roommate interview	Frequency of binge drinking among roommate Closeness among roommates	Logistic regression	Peer effects for binge drinking are significant among men and women. Peer effects for binge drinking are stronger for students who did not binge drink prior to college. Matching of baseline substance use behaviors between roommates significantly predicts friendships.

Study	Objective	Study details <sup>1</sup>	Study design	Data sources	Social network measure(s)	Statistical analyses <sup>2</sup>	Major findings related to the social network analyses
Giese et al. (2017)	Explore the role of friendship reciprocity in shaping frequency and quantity of alcohol consumption among university Freshmen	Germany 57 first semester psychology students at the University of Konstanz from 2008-2009 20.9 years = mean age (at baseline) 25% male	Longitudinal	Interview with SNQ that asked participants to nominate the 3 people that they liked most that week from the full list of participants	Outdegree nominations and indegree nominations	Multilevel regression models	Participants' frequency of drinking was associated with reciprocating friends' frequency of drinking. Participants' quantity of drinking was associated with friends' quantity of drinking regardless of reciprocation.
Hahm et al. (2012)	Describe the proportion of binge drinking Analyze long-term changes of binge drinking status by social network structures measured in adolescence.	US; National Longitudinal Study of Adolescent Health in 2001-2002 15,197 participants age range: 18 to 27 46% male	Longitudinal	Interview with SNQ that featured complete school rosters and students were asked to nominate 5 male and 5 female friends.	group integration, prestige, density, and proximity to the best friend's substance use	Appropriate multivariate analyses using GEE to account for repeated measures	48% of participants reported binge drinking as young adults Centrality and having alcohol-using friends were both associated with binge drinking in young adulthood. Social network effects, in general, decreased from adolescence to young adulthood, except for centrality; therefore the risk factors for binge drinking during adolescence do not necessarily carry over through young adulthood, regardless of how robust the impact was during adolescence.
Hussong et al. (2003)	Test whether drinking motives mediate the relation between personality and alcohol use and whether these predictors affect drinking in an individuals' friends.	US 86 same-gendered best friends (43 dyads) at a large, SE state university 18 years = mean 49% male	Longitudinal	1.5-hr session in which observational assessments and a survey were completed An experience-sampling protocol involving daily assessments of substance use over the 28-day period following the initial visit	Friend's personality, friend's drinking motives, friend's frequency of alcohol use and friend's frequency of heavy alcohol use	Structural equation modeling	Young adults' alcohol use was influenced by the drinking motives of their best friends.



Study	Objective	Study details <sup>1</sup>	Study design	Data sources	Social network measure(s)	Statistical analyses <sup>2</sup>	Major findings related to the social network analyses
Janulis et al. (2015)	Examine relationships between network (i.e., transitivity and network size), dyadic (e.g., age difference), and individual characteristics and drug and alcohol behavior with substance use alters to better understand the social and contextual factors associated with substance use behavior among YMSM.	US 156 young men who have sex with men 20.1 years = mean age (at baseline) 100% male	Cross-sectional	Individual interviews and RDS recruitment data	Transitivity, network size, dyadic frequency and type of drug use	Logistic mixed models with random intercepts	An ego's drug use and an ego's frequency of drug and alcohol use with substance use alters were positively associated with the network transitivity of their substance use network. Thus, the ties between alters that an individual uses substances with is related to the type and frequency of substance use with those alters.
Kenney et al. (2017)	Examined how misperceptions of residence hall peers, both overall using a global question and those designated as important peers using person-specific questions, were related to students' personal drinking behaviors.	US 108 students living on a college campus in the NE 49% male	Cross-sectional	Interview with SNQ of up to 10 people who lived in the residence hall	Self-reported and peer-reported alcohol consumption	Network autocorrelation models	Participants accurately perceived the drinking of nominated friends but overestimated the drinking of residential peers. Misperceptions of peer drinking predicted personal drinking behavior.

Study	Objective	Study details <sup>1</sup>	Study design	Data sources	Social network measure(s)	Statistical analyses <sup>2</sup>	Major findings related to the social network analyses
Latkin et al. (1996)	Examine the prospective association between baseline self-reported drug and alcohol use of the network members of injection drug users, and self-reported sexual behaviors and alcohol use at 5-month follow-up.	US 71 nontreatment inner-city injection drug users who volunteered for a network-oriented HIV preventive intervention and 227 members of their drug networks from 1991-1992 38 years = mean age 85% male	Longitudinal	Detailed, face-to-face interview on background, HIV-related behaviors in the prior 6 months, and SNQ where they were required to provide names and descriptive information on their network members. Indexes were compensated \$25 for each drug-sharing network member that came in to be interviewed.	Drug networks' mean baseline level of alcohol consumption	Prospective multiple logistic regression	Drug networks' mean baseline level of alcohol consumption was a significant predictor of indexes' daily alcohol consumption in the prior six months.
Lau et al. (1990)	Explore sources of stability and change in young adults' beliefs and behavior concerning drinking during the first 3 years of college	US 947 students admitted to Carnegie Mellon University and their parents 69% male 18 years = mean age (at baseline)	Longitudinal	Interviews among participants, their parents and up to 2 other participants in the study- roommates and people named by the youths as their best friends at college.	Parents' alcohol beliefs, parents' alcohol consumption, peers' alcohol beliefs, peers' alcohol consumption,	Structural equations analysis with latent variables	Parental influence on their children's drinking beliefs and drinking behavior are present at baseline and persist, despite weakening, at least through the college years. Peers drinking behavior was associated with participant's drinking behavior.
Lorant et al. (2015)	Analyze the role of peers and of social position within a university network in drinking behavior.	Belgium 487 undergraduates in 2 faculties (Engineering and Psychology) in a university in 2010 45% male	Cross-sectional	Paper-pencil questionnaires with SNQ where participants were provided with a complete list of all students to identify those with whom they had the following relationships: friends, roommates, studying or working with, and spending leisure time with.	In-degree centrality, closeness, cross-gender relationships, social capital (i.e. effective size)	Poisson regression with permutation tests to assess the distribution of the estimates.	Being socially close to binge drinkers was associated with a higher frequency of binge drinking; higher for reciprocated ties than non-reciprocated. The risk of binge drinking increased with centrality but decreased with social capital. Having cross-gender relationships decreased the risk of binge drinking. The effect of centrality and gender on binge drinking depends on the composition of the network.

Study	Objective	Study details <sup>1</sup>	Study design	Data sources	Social network measure(s)	Statistical analyses <sup>2</sup>	Major findings related to the social network analyses
Ott et al. (2016)	Learn about the unknown average number of alcoholic drinks consumed on drinking days and the association between certain personal characteristics and alcohol consumption	US 125 students living on a college campus in the NE who nominated other network members or who were nominated by other network members 47% male	Cross-sectional	Interview with SNQ of up to 10 people who lived in the residence hall	Self-reported and peer-reported alcohol consumption	Novel Bayesian comparative calibration model that uses covariate information to characterize the joint distribution of both self and peer-reports on the network for estimating discrepancies in network surveys, then applied to the data for full Bayesian inference.	Use of peer-reports improves estimates of self-reported alcohol consumption Peer-reports of alcohol consumption are overestimates. Men tended to have larger discrepancies than women.
Overbeek et al. (2010)	Assess the relative importance of best friends' alcohol use versus general levels of alcohol use in the peer setting for predicting young adults' alcohol use	Netherlands 221 young adults in 28 peer groups 46% male majority groups	Naturalistic observation study	10-minute questionnaire followed by 2 hours observed drinking in a bar-lab	Peers' quantity of alcohol consumption during the observation period	Multilevel regression analysis using both fixed and random effects	Average peer group levels of alcohol consumption was the strongest predictor of youths' alcohol consumption in an experimental setting. This finding was less pronounced for females.
Phua (2011)	Examine the influence of popularity and conforming to perceived peer norms on smoking and drinking among college fraternity members using social network analysis	US; college fraternity at private university in SW 34 freshmen pledges 20.1 years = mean age (at time period 1) 100% male	Longitudinal	Interview with SNQ of other fraternity members	Homophily Popularity (indegree nominations)	ANOVA density models Quadratic Assignment Procedure correlation analyses	The network became more homophilous with regards to drinking. Popularity in the fraternity network significantly predicts heavier drinking (i.e. the more popular a member the more likely he is to be a heavier drinker)

Study	Objective	Study details <sup>1</sup>	Study design	Data sources	Social network measure(s)	Statistical analyses <sup>2</sup>	Major findings related to the social network analyses
Rosenquist et al. (2010)	Explore quantitatively whether alcohol consumption behavior spreads from person to person in a large social network of friends, coworkers, siblings, spouses, and neighbors, followed for 32 years.	US: The Framingham Heart Study 12,067 persons assessed at several time points between 1971 - 2003. 50.9 years = mean age 48% male	Longitudinal	Participant data, collected every 2 to 4 years, includes physical examinations, laboratory tests, noninvasive cardiac and vascular testing, battery testing, questionnaire results, demographic information, and SNQ self-described social ties, collected in each of the 7 waves of the study.	Alcohol consumption of social network ties at various degrees of separation. Clustering in alcohol consumption (homophily, confounding, induction)	Longitudinal logistic regression models using GEE to account for multiple observations Observed clustering of alcohol consumption within the network compared with 1000 simulated networks with same topology and prevalence of drinking as the observed network, but with the incidence of drinking randomly distributed across nodes.	Participants are 50% more likely to drink heavily if a person they are directly connected drinks heavily. The size of the effect is 36% for people at 2 degrees of separation and 15% for people at 3 degrees of separation. The effect disappears at 4 degrees of separation. Each heavy drinker in a participant's social network increased the likelihood of drinking heavily by 18% and decreased the likelihood of abstinence by 7% but had no effect on moderate alcohol consumption behavior. Female contacts are significantly more likely than male contacts to influence the spread of heavy alcohol consumption.
Tucker et al. (2015)	Investigated whether substance use among emerging adults living in disadvantaged urban areas was influenced by peer and family social network messages that variously encouraged and discouraged substance use.	US, Birmingham, Alabama 344 residents of lower income neighborhoods recruited via RDS 18.9 years = mean age 68% female	Cross-sectional	Individual 1.5-hour interviews and RDS recruitment data	Peer substance users in participants' immediate social networks	Linear regression	Substance use (alcohol and other drugs) by close network members was associated with global substance involvement but not alcohol involvement, specifically.

<sup>1</sup>Participant age and sex and study dates are included if it was reported in the article

<sup>2</sup>Includes statistical tests that specifically incorporated network measures

Notes: SNA = social network analysis; SNQ = social network questionnaire; RDS = Respondent driven sampling

## References

1. Smith KP, Christakis NA. Social networks and health. *Annual Review of Sociology*. 2008;34:405-29.
2. Valente TW, Gallaher P, Mouttapa M. Using social networks to understand and prevent substance use: a transdisciplinary perspective. *Substance use & misuse*. 2004;39(10-12):1685-712.
3. Smith KP, Christakis NA. Social networks and health. *Annu Rev Sociol*. 2008;34:405-29.
4. Israel BA. Social networks and health-status - Linking theory, research, and practice. *Patient Counselling and Health Education*. 1982;4(2):65-79.
5. Umberson D, Montez JK. Social relationships and health: A flashpoint for health policy. *J Health Soc Behav*. 2010;51:S54-S66.
6. Johnson BT, Redding CA, DiClemente RJ, Mustanski BS, Dodge B, Sheeran P, et al. A network-individual-resource model for HIV prevention. *AIDS and behavior*. 2010;14:S204-S21.
7. Berkman LF, Glass T. Social integration, social networks, social support, and health. In: Berkman LF, Kawachi I, editors. *Social epidemiology*. New York: Oxford University Press; 2000. p. 137-73.
8. Kottiri BJ, Friedman SR, Neaigus A, Curtis R, Des Jarlais DC. Risk networks and racial/ethnic differences in the prevalence of HIV infection among injection drug users. *Journal of Acquired Immune Deficiency Syndromes*. 2002;30(1):95-104.
9. Friedman SR, Aral S. Social networks, risk-potential networks, health, and disease. *Journal of Urban Health*. 2001;78(3):411-8.
10. Friedman SR, Neaigus A, Jose B, Curtis R, Goldstein M, Idefonso G, et al. Sociometric risk networks and risk for HIV infection. *American Journal of Public Health*. 1997;87(8):1289-96.
11. Valente TW. Network interventions. *Science*. 2012;337(6090):49-53.
12. Alexander C, Piazza M, Mekos D, Valente T. Peers, schools, and adolescent cigarette smoking. *The Journal of adolescent health : official publication of the Society for Adolescent Medicine*. 2001;29(1):22-30.
13. Smith AMA, Grierson J, Wain D, Pitts M, Pattison P. Associations between the sexual behaviour of men who have sex with men and the structure and composition of their social networks. *Sexually transmitted infections*. 2004;80(6):455-8.
14. HELLERINGER S, KOHLER HP. Sexual network structure and the spread of HIV in Africa: evidence from Likoma Island, Malawi. *Aids*. 2007;21(17):2323-32.
15. Choi KH, Ning Z, Gregorich SE, Pan QC. The influence of social and sexual networks in the spread of HIV and syphilis among men who have sex with men in Shanghai, China. *Journal of Acquired Immune Deficiency Syndromes*. 2007;45(1):77-84.
16. Laumann EO, Youm Y. Racial/ethnic group differences in the prevalence of sexually transmitted diseases in the United States: A network explanation. *Sexually Transmitted Diseases*. 1999;26(5):250-61.
17. Youm Y, Laumann EO. Social network effects on the transmission of sexually transmitted diseases. *Sexually Transmitted Diseases*. 2002;29(11):689-97.
18. Kelly JA, Amirkhanian YA, Seal DW, Galletly CM, DiFranceisco W, Glasman LR, et al. Levels and predictors of sexual HIV risk in social networks of men who have sex with men in the Midwest. *AIDS Education and Prevention*. 2010;22(6):483-95.

19. Doherty IA, Padian NS, Marlow C, Aral SO. Determinants and consequences of sexual networks as they affect the spread of sexually transmitted infections. *Journal of Infectious Diseases*. 2005;191:S42-S54.
20. Broadhead RS, Heckathorn DD, Weakliem DL, Anthony DL, Madray H, Mills RJ, et al. Harnessing peer networks as an instrument for AIDS prevention: results from a peer-driven intervention. *Public health reports*. 1998;113 Suppl 1:42-57.
21. Latkin CA. Outreach in natural settings: the use of peer leaders for HIV prevention among injecting drug users' networks. *Public health reports*. 1998;113 Suppl 1:151-9.
22. Latkin C, Donnell D, Celentano DD, Aramrattna A, Liu TY, Vongchak T, et al. Relationships between social norms, social network characteristics, and HIV risk behaviors in Thailand and the United States. *Health Psychol*. 2009;28(3):323-9.
23. Luke DA, Harris JK. Network analysis in public health: History, methods, and applications. *Annu Rev Publ Health*. 2007;28:69-93.
24. Friedman SR, Bolyard M, Mateu-Gelabert P, Goltzman P, Pawlowicz MP, Singh DZ, et al. Some data-driven reflections on priorities in AIDS network research. *AIDS and behavior*. 2007;11(5):641-51.
25. Valente TW, Fosados R. Diffusion of innovations and network segmentation: The part played by people in promoting health. *Sexually Transmitted Diseases*. 2006;33(7):S23-S31.
26. Christakis NA, Fowler JH. The spread of obesity in a large social network over 32 years. *N Engl J Med*. 2007;357(4):370-9.
27. Cohen-Cole E, Fletcher JM. Is obesity contagious? Social networks vs. environmental factors in the obesity epidemic. *J Health Econ*. 2008;27(5):1382-7.
28. Cohen-Cole E, Fletcher JM. Detecting implausible social network effects in acne, height, and headaches: longitudinal analysis. *BMJ*. 2008;337:a2533.
29. Ali MM, Dwyer DS. Social network effects in alcohol consumption among adolescents. *Addictive behaviors*. 2010;35(4):337-42.
30. Balsa AI, Homer JF, French MT, Norton EC. Alcohol Use and Popularity: Social Payoffs from Conforming to Peers' Behavior. *J Res Adolesc*. 2011;21(3):559-68.
31. Cheadle JE, Stevens M, Williams DT, Goosby BJ. The differential contributions of teen drinking homophily to new and existing friendships: An empirical assessment of assortative and proximity selection mechanisms. *Soc Sci Res*. 2013;42(5):1297-310.
32. Cruz JE, Emery RE, Turkheimer E. Peer network drinking predicts increased alcohol use from adolescence to early adulthood after controlling for genetic and shared environmental selection. *Dev Psychol*. 2012;48(5):1390-402.
33. Deutsch AR, Chernyavskiy P, Steinley D, Slutske WS. Measuring peer socialization for adolescent substance use: a comparison of perceived and actual friends' substance use effects. *J Stud Alcohol Drugs*. 2015;76(2):267-77.
34. Deutsch AR, Steinley D, Slutske WS. The role of gender and friends' gender on peer socialization of adolescent drinking: a prospective multilevel social network analysis. *J Youth Adolesc*. 2014;43(9):1421-35.
35. Hatzenbuehler ML, McLaughlin KA, Xuan Z. Social networks and sexual orientation disparities in tobacco and alcohol use. *J Stud Alcohol Drugs*. 2015;76(1):117-26.
36. Mundt MP. The impact of peer social networks on adolescent alcohol use initiation. *Acad Pediatr*. 2011;11(5):414-21.
37. Room R, Babor T, Rehm J. Alcohol and public health. *Lancet*. 2005;365(9458):519-30.

38. Rehm J, Gmel G, Sempos CT, Trevisan M. Alcohol-related morbidity and mortality. *Alcohol Res Health*. 2003;27(1):39-51.
39. Rehm J. Alcohol and all-cause mortality. *Int J Epidemiol*. 1996;25(1):215-6; author reply 8-20.
40. Valente TW. Social network influences on adolescent substance use: an introduction. *Connections*. 2003;25(2):11-6.
41. Windle M. Parental, sibling, and peer influences on adolescent substance use and alcohol problems. *Applied Developmental Science*. 2000;4:98-110.
42. Gaughan M. Predisposition and pressure: mutual influence and adolescent drunkenness. *Connections*. 2003;25(2):17-31.
43. K.C. J, P. G. US adolescents' friendship networks and health risk behaviors: a systematic review of studies using social network analysis and Add Health data. *PeerJ*. 2015;3:e1052.
44. W.W. H, N. S. Friendships and adaptation in the life course. *Psychological bulletin*. 1997 121(3):355-70.
45. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Med*. 2009;6(7):e1000100.
46. Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med*. 2009;6(7):e1000097.
47. Lo CK, Mertz D, Loeb M. Newcastle-Ottawa Scale: comparing reviewers' to authors' assessments. *BMC Med Res Methodol*. 2014;14:45.
48. Cunningham FC, Ranmuthugala G, Plumb J, Georgiou A, Westbrook JI, Braithwaite J. Health professional networks as a vector for improving healthcare quality and safety: a systematic review. *BMJ Qual Saf*. 2012;21(3):239-49.
49. Russell CK, Gregory DM. Evaluation of qualitative research studies. *Evid Based Nurs*. 2003;6(2):36-40.
50. Andrews JA, Tildesley E, Hops H, Li F. The influence of peers on young adult substance use. *Health Psychol*. 2002;21(4):349-57.
51. Barnett NP, Ott MQ, Clark MA. The relevance of network prominence and reciprocity of relationships for alcohol use and alcohol-related problems in a college residence hall network. *Psychology of addictive behaviors : journal of the Society of Psychologists in Addictive Behaviors*. 2014;28(4):980-9.
52. Barnett NP, Ott MQ, Rogers ML, Loxley M, Linkletter C, Clark MA. Peer associations for substance use and exercise in a college student social network. *Health Psychol*. 2014;33(10):1134-42.
53. Duncan GJ, Boisjoly J, Kremer M, Levy DM, Eccles J. Peer effects in drug use and sex among college students. *J Abnorm Child Psychol*. 2005;33(3):375-85.
54. Eisenberg D, Golberstein E, Whitlock JL. Peer effects on risky behaviors: new evidence from college roommate assignments. *J Health Econ*. 2014;33:126-38.
55. Giese H, Stok FM, Renner B. The role of friendship reciprocity in university freshmen's alcohol consumption. *Applied psychology Health and well-being*. 2017.

56. Hahm HC, Kolaczyk E, Jang J, Swenson T, Bhindarwala AM. Binge drinking trajectories from adolescence to young adulthood: the effects of peer social network. *Substance use & misuse*. 2012;47(6):745-56.
57. Hussong AM. Social influences in motivated drinking among college students. *Psychology of addictive behaviors : journal of the Society of Psychologists in Addictive Behaviors*. 2003;17(2):142-50.
58. Janulis P, Birkett M, Phillips G, 2nd, Mustanski B. Substance use network characteristics and drug and alcohol use behaviors among young men who have sex with men (YMSM). *Drug and alcohol dependence*. 2015;157:188-91.
59. Kenney SR, Ott M, Meisel MK, Barnett NP. Alcohol perceptions and behavior in a residential peer social network. *Addictive behaviors*. 2017;64:143-7.
60. Latkin CA, Mandell W, Vlahov D. The relationship between risk networks' patterns of crack cocaine and alcohol consumption and HIV-related sexual behaviors among adult injection drug users: a prospective study. *Drug and alcohol dependence*. 1996;42(3):175-81.
61. Lau RR, Quadrel MJ, Hartman KA. Development and change of young adults' preventive health beliefs and behavior: influence from parents and peers. *J Health Soc Behav*. 1990;31(3):240-59.
62. Lorant V, Nicaise P. Binge drinking at university: a social network study in Belgium. *Health promotion international*. 2015;30(3):675-83.
63. Ott MQ, Hogan JW, Gile KJ, Linkletter C, Barnett NP. Bayesian peer calibration with application to alcohol use. *Statistics in medicine*. 2016;35(19):3303-18.
64. Overbeek G, Bot SM, Meeus WHJ, Sentse M, Knibbe RA, Engels R. Where it's at! The role of best friends and peer group members in young adults' alcohol use. *Journal of Research on Adolescence*. 2011;213(3):631-8.
65. Phua J. The influence of peer norms and popularity on smoking and drinking behavior among college fraternity members: a social network analysis. *Social Influence*. 2011;6(3):153-68.
66. Rosenquist JN, Murabito J, Fowler JH, Christakis NA. The spread of alcohol consumption behavior in a large social network. *Annals of internal medicine*. 2010;152(7):426-33, w141.
67. Tucker JA, Cheong JW, Chandler SD, Crawford SM, Simpson CA. Social networks and substance use among at-risk emerging adults living in disadvantaged urban areas in the southern United States: a cross-sectional naturalistic study. *Addiction*. 2015;110(9):1524-32.



## Appendix

Table A 2.1. PRISMA 2009 checklist

Section/topic	#	Checklist item	Reported on page #
<b>TITLE</b>			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	13
<b>ABSTRACT</b>			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Reported separately
<b>INTRODUCTION</b>			
Rationale	3	Describe the rationale for the review in the context of what is already known.	13-14
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	14
<b>METHODS</b>			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	N/A
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	15
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	15, Table A 2.2
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Table A 2.2
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	15-16
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	16

Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	16
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	16, Tables A 2.3-A 2.4
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	N/A
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., $I^2$ ) for each meta-analysis.	16
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/A
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
<b>RESULTS</b>			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Figure 2.1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Tables 2.2-2.3
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Table A 2.4
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Table 2.3
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	N/A
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
<b>DISCUSSION</b>			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	19-20

Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	20-21
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	21
<b>FUNDING</b>			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Reported separately

Table A 2.2. Literature review database search strategy and terms

Database	Search strategy and terms	Records identified
PubMed/M EDLINE	((((((("alcohol use" OR "alcohol user" OR "alcohol users" OR "alcohol misuse" OR "alcohol abuse" OR "alcohol abuser" OR "alcohol abusers" OR "alcohol addict" OR "alcohol addicts" OR "alcohol dependence" OR "alcohol dependent")) OR ("drinker" OR "drinkers" OR "drinking" OR "alcoholic" OR "alcoholics")) OR "Alcohol-Related Disorders" [mh:noexp]) OR "Alcoholic Intoxication" [mh:noexp]) OR "Alcoholism" [mh:noexp]) OR "Binge Drinking" [mh:noexp])) AND ((("Social Support"[Mesh]) OR (((((((("social network" OR "social networks" OR "network analysis" OR "network analyses" OR "friendship network" OR "friendship networks" OR "peer networks" OR "peer network"))	2029
EMBASE	("alcohol use" or "alcohol user" or "alcohol users" or "alcohol misuse" or "alcohol abuse" or "alcohol abuser" or "alcohol abusers" or "alcohol addict" or "alcohol addicts" or "alcohol dependence" or "alcohol dependent").mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word] Or ("drinker" or "drinkers" or "drinking" or "alcoholic" or "alcoholics").mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word] Or alcoholism/ or alcohol abuse/ And ("social network" or "social networks" or "network analysis" or "network analyses" or "friendship network" or "friendship networks" or "peer networks" or "peer network").mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word] Or Social network/ Or Social support/	1909
PsycINFO	("alcohol use" or "alcohol user" or "alcohol users" or "alcohol misuse" or "alcohol abuse" or "alcohol abuser" or "alcohol abusers" or "alcohol addict" or "alcohol addicts" or "alcohol dependence" or "alcohol dependent").mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word] Or ("drinker" or "drinkers" or "drinking" or "alcoholic" or "alcoholics").mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word] Or alcoholism/ or alcohol abuse/ And	879

("social network" or "social networks" or "network analysis" or "network analyses" or "friendship network" or "friendship networks" or "peer networks" or "peer network").mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word]

Or

Social networks/ or social support/

Web of  
Science

("alcohol use" OR "alcohol user" OR "alcohol users" OR "alcohol misuse" OR "alcohol abuse" OR "alcohol abuser" OR "alcohol abusers" OR "alcohol addict" OR "alcohol addicts" OR "alcohol dependence" OR "alcohol dependent" OR "drinker" OR "drinkers" OR "drinking" OR "alcoholic" OR "alcoholics") AND TOPIC: ("social network" OR "social networks" OR "network analysis" OR "network analyses" OR "friendship network" OR "friendship networks" OR "peer networks" OR "peer network")

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Table A 2.3. Quality assessment tool

1. Is the research question clear and adequately substantiated?  
0 = Inadequately described  
1 = Adequately described  
2 = Very clear and well substantiated
2. Does the study include dates and sources for data collection?  
0 = No  
1 = Yes
3. Is the description of the study setting adequate?  
0 = No  
1 = Yes
4. Adequate sample size, where applicable  
0 = No or cannot be determined  
1 = Yes  
Not applicable
5. Adequate response rate (>60%), where applicable  
0 = No or cannot be determined  
1 = Yes  
Not applicable
6. Adequate sample selection  
0 = No or cannot be determined  
1 = Yes
7. Exposure measurement: Does the study clearly describe collection of social network data (i.e., sociometric interviews)?  
0 = No description  
1 = Mentioned, little description  
2 = Detailed description
8. Outcome measurement: Does the study clearly describe the outcome measure?  
0 = No description of case definition  
1 = Self-reported by participant  
2 = Used a validated measure or provided valid justification for not doing so
9. Social network analysis  
0 = No social network measures calculated  
1 = Social network measures calculated but not correlated with outcome  
2 = Social network measures calculated and correlated with outcome and/or used to define comparison groups
10. Is the description of findings thorough and are the data presented adequately?  
0 = No  
1 = Adequate  
2 = Very thorough
11. Are the strengths and limitations adequately considered?  
0 = No  
1 = Yes
12. Are the study conclusions supported by the results?  
0 = No  
1 = Possibly  
2 = Yes

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Table A 2.4. Quality assessment of articles selected for review

Article	1. Research question	2. Data collection	3. Study setting	4. Sample size	5. Response rate	6. Sample selection	7. Exposure measurement	8. Outcome measurement	9. Social network analysis	10. Findings and data presentation	11. Strengths and limitations	12. Conclusions	Quality score
Andrews et al. (2002)	2	1	1	1	1	1	2	1	2	2	1	2	94%
Barnett et al. (2014a)	2	1	1	1	1	1	2	2	2	2	1	2	100%
Barnett et al. (2014b)	1	1	1	1	1	1	1	2	2	1	1	2	83%
Duncan et al. (2005)	2	1	1	1	1	1	2	2	2	2	1	2	100%
Eisenberg et al. (2014)	2	1	1	1	1	1	2	2	2	2	1	2	100%
Giese et al. (2017)	2	1	1	1	1	1	2	2	2	1	1	2	94%
Hahm et al. (2012)	2	1	1	1	1	1	2	1	2	1	1	2	89%
Hussong et al. (2003)	2	1	1	1	1	1	2	2	2	2	1	2	100%
Janulis et al. (2015)	2	1	1	1	1	1	2	1	2	1	1	2	89%
Kenney et al. (2017)	2	1	1	1	1	1	2	2	2	2	1	2	100%
Latkin et al. (1996)	2	1	1	1	1	1	2	1	2	2	1	2	94%
Lau et al. (1990)	1	1	1	1	1	1	2	2	2	1	1	1	89%
Lorant et al. (2015)	2	1	1	1	1	1	2	2	2	2	1	2	100%
Ott et al. (2016)	2	1	1	1	1	1	2	2	2	2	1	2	100%

Article	1. Research question	2. Data collection	3. Study setting	4. Sample size	5. Response rate	6. Sample selection	7. Exposure measurement	8. Outcome measurement	9. Social network analysis	10. Findings and data presentation	11. Strengths and limitations	12. Conclusions	Quality score
Overbeek et al. (2010)	2	1	1	1	1	1	2	2	2	2	1	2	100%
Phua (2011)	1	1	1	1	1	1	2	1	2	1	1	1	78%
Rosenquist et al. (2010)	2	1	1	1	1	1	2	2	2	2	1	2	100%
Tucker et al. (2015)	2	1	1	1	1	1	2	2	1	2	1	2	94%



## **Chapter 3 Determinants of hazardous drinking among black South African MSM**

### **Introduction**

Black South African men who have sex with men (MSM) consume high levels of alcohol (1-3). In one study, nearly two thirds of men reported drinking regularly, with nearly half reporting that they get drunk regularly (2). In another study, over half of men reported having 10 or more drinks in a typical day of drinking and more than three quarters of men were classified as having a drinking problem (3). In another study, nearly three quarters of men reported having sex while under the influence of alcohol (1). Alcohol use and abuse constitutes a major public health problem, contributing to injury, disease and death. Hazardous drinking is of particular concern among this population due to the high prevalence of HIV, which estimates range between 13% and 50% (1, 3, 4), and the increased risk of HIV infection associated with excessive drinking (5-8). Alcohol use has also been shown to have negative health consequences among people living with HIV, including lack of viral suppression, common comorbid conditions, and ultimately morbidity and mortality through both biological and behavioral mechanisms (9). Despite the known burden of hazardous drinking and its associated health risks, no study to date has identified risk factors for hazardous drinking among black South African MSM, nor any other African MSM population (10).

Researchers have observed elevated rates of concurrent psychosocial problems, including heavy alcohol use, among non-African LGBT populations (11-16), noting that they work synergistically to increase risk of HIV infection (16, 17). For example, mental health problems, including anxiety (18), and depression (19), often co-occur with substance use disorders, particularly alcohol dependence (13). Sexual minority stressors, such as internalized homophobia and external homophobia (i.e. experiences with sexual orientation-related discrimination), are

associated with increased alcohol-related problems (13, 14), and are likely of heightened importance among black South African MSM where same-sex sexuality is highly stigmatized (20-25). Social network characteristics are also potential determinants of hazardous drinking as social networks are known to play a major role in many health-related behaviors (26-32). For example, the drinking behavior of an individual's social network members often provides a crucial context for individual decisions on how much and how often to drink (33). One's degree of connectedness to a specific social network has been found to be positively associated with one's likelihood of reflecting the normative behavior of that group regarding substance use (34). Peers' alcohol use has been found to be a primary influence on an individual's alcohol use (35, 36). There is also a potential heightened importance of social networks among stigmatized populations, such as black South African MSM (37).

This paper aims to describe alcohol use among black South African MSM and identify determinants that put them at risk for hazardous drinking. The data for this project were collected among black MSM living in Tshwane, South Africa. These men currently live in or have recently moved from township communities. Township communities are peri-urban areas (the landscape interface between town and country) previously segregated under Apartheid whose residents continue to be characterized by limited resources, low levels of education, and high rates of unemployment. Personal social networks are the primary context in which these men learn how to express their sexuality, deal with stigma, and manage the risks of unprotected sex (38). They meet potential sex partners predominantly through these social networks or at drinking establishments. These circumstances combine to create a context where substance use, particularly excessive substance use, is normative (1, 2, 4). Respondent-driven sampling (RDS)

was chosen as the method to recruit these men because it is the most reliable way to derive valid population estimates for hidden populations such as black South African MSM (39).

## **Methods**

### *Study population and procedures*

The data used for the current project was collected as part of a study whose primary objective was to determine the prevalence of HIV infection among black MSM in Tshwane (4).

Participants were recruited using RDS (40, 41). Eligibility criteria for study participation included age older than 18; having engaged in oral, anal, or masturbatory sex with another man in the prior 12 months; living, working, or socializing in the Tshwane metro area; fluency in English, Sepedi (Northern Sotho), or isiZulu; and willingness to take an HIV rapid test.

Consistent with RDS methodology, seeds, 20 in total, distributed up to five coupons to eligible men from their social networks who they were willing to recruit into the study. The seeds were referred by the community advisory board, screened to ensure that they met all of the study eligibility criteria and then interviewed about their social network size and composition. All seeds were Black and were purposively selected based on geographic place of residence in the Tshwane metro area and age. Men enrolled in the study and completed study procedures, including a 90-minute interviewer-administered computer-assisted personal interview and an HIV blood test, which was conducted following a serial algorithm in accordance with South African national guidelines. All participants were screened by licensed nurses using two licensed rapid test kits (EZ Trust HIV 1 & 2, CS Innovation; First Response, Premier Medical Corporation). Non-reactive samples were interpreted as negative. Samples that were reactive on both tests were confirmed as positive. There were no indeterminate results. Staff provided participants with up to five recruitment coupons for further distribution. All study participants

received vouchers worth 150 South African Rand (~\$12 US Dollars) to be redeemed at a supermarket as primary incentive for their own participation, as well as additional vouchers worth 50 South African Rand (~\$4 US Dollars) as secondary incentives for each successful referral to the study. At one point, verification of the inclusion criteria was expanded in order to ensure that all participants met the inclusion criteria. We did not observe evidence of anything else that might have threatened the integrity of the recruitment process. Participants were linked to their referral chain using their coupon identification numbers. All study procedures were approved by the Institutional Review Board of the New York State Psychiatric Institute in the U.S. and the Research Ethics Committee of the Human Sciences Research Council in South Africa. Participants provided written informed consent for the survey. Study staff provided referrals for further HIV testing and counseling, mental health, or primary care as indicated.

### *Measures*

Scales adapted for and previously validated in South Africa were used whenever possible. Multiple aspects of alcohol use practices were evaluated (42, 43). First, men were asked if they ever drank alcohol, then if they drank alcohol in the past year. Men replied ‘yes’ or ‘no’. They were then asked where they drink and what they drink. They were also asked if they drink before going out, if they pay for their own drinks, if they buy drinks for men that they want to have sex with, or if men who want to have sex with them buy them drinks. Men replied on 5-point scales (e.g. “Never” (0) – “Always” (4)). Hazardous drinking was evaluated using the Alcohol Use Disorders Identification Test - Consumption (AUDIT- C), (44, 45), a scale developed and validated by the World Health Organization for international use, including in South Africa (44-46), where it has been used in multiple studies (47-49). The AUDIT-C uses 3 items: how often the respondent drinks, how many drinks the respondent consumes in a typical day of drinking,

and how frequently the respondent drinks six or more drinks at a time. Of a maximum score of 12 on the AUDIT-C, a score of four or more indicates hazardous drinking for men (50). Drug use practices were measured by asking men if they had ever used marijuana, poppers, cocaine, opiates, hallucinogens, amphetamines, and other club drugs. If they replied yes to any of these, they were asked if they had used them in the past year.

The survey also measured demographic characteristics (age, education, income, residence), psychosocial factors and behavioral attributes. Men's reasons for drinking were assessed using eleven items (51), representing three domains: drinking for a positive affect ( $\alpha = 0.87$ ), drinking to cope with negative affect ( $\alpha = 0.91$ ) and drinking to enhance social interactions ( $\alpha = 0.80$ ); (overall  $\alpha = 0.95$ ). A sample item on the drinking to enhance social interactions scale is: "In the past year, how often did you drink because a drink helps you to have better sex?". Men replied on a five-point scale ("Never" (1) – "Always" (5)). Men who did not drink were assigned to "Never" (1) on all of these items. The Sex-Related Alcohol Expectancy Scale (52, 53) was used to assess men's expectancies about the effects of alcohol use on sexual behavior, representing three domains: enhancement of sexual experience ( $\alpha = 0.93$ ), increased sexual risk taking ( $\alpha = 0.91$ ), and disinhibition of sexual behavior ( $\alpha = 0.88$ ) (54, 55); (overall  $\alpha = 0.95$ ). A sample item is: "After a few drinks of alcohol I am more sexually responsive". Men replied on a 4-point Likert scale ("Strongly disagree" (1) - "Strongly agree" (4)). Sexual attraction was assessed with the question "Do you currently feel more sexually attracted to men or to women?" and a 5-point response scale (1="Only to women"; 5="Only to men"). Men were coded as 'Only attracted to men' and 'Also attracted to women' because of the distribution of the participants' responses. Sexual identification was assessed with the question "What word would you use to describe your sexuality? Would you call yourself gay, bisexual, or straight, or would you use another word?"

There were a few men (n=2) who described themselves as transgender and they were grouped with other gay men because of how they overlapped in terms of other measures of sexual identity (e.g. masculinity/femininity, sexual attraction to women, etc.). There were also a few straight men (n=15) who reported sex with other men in the previous 12 months who were grouped with bisexual men because of how they overlapped in terms of other measures of sexual identity. Self-perceived masculinity/femininity was assessed with a 6-item scale with 3 items assessing level of masculinity and femininity each (56) ( $\alpha = 0.95$ ). Sexual identity confusion and internalized homophobia were assessed with subscales adapted from the Lesbian, Gay, and Bisexual Identity Scale (LGBIS) (57, 58). Sexual identity confusion was assessed with 4-items (e.g., “I am not totally sure what my sexual orientation is”) ( $\alpha = 0.89$ ). Internalized homophobia was assessed with 7-items (e.g., “I wish I were only sexually attracted to women”) ( $\alpha = 0.85$ ). Secrecy about one’s sexual orientation was assessed with a 8-item scale (59) ( $\alpha = 0.96$ ). Gender dysphoria was assessed over the past year using a 16-item scaled adapted from the Gender Identity/Gender Dysphoria Questionnaire for Adolescents and Adults (60, 61) ( $\alpha = 0.93$ ). Sample items include: “How often have you thought of yourself as a woman in the past 12 months?” and “How often have you felt unhappy about having a male body in the past 12 months?” and used a 5-point response scale (1=“Never”; 5=“Always”). Sexual orientation-based discrimination was assessed using a 10-item scale asking how often in the past year men had experienced such things as verbal insults, threats of physical violence, sexually harassment or rape because of having sex with men; items used a 4-point response scale (0=“Never”; 4=“Often”) ( $\alpha = 0.87$ ). Men were also asked if they had ever experienced sexual abuse as a child, and if they ever received money or other incentives in return for sex (transactional sex). The survey also had brief screening questions for two mental health conditions: anxiety and depression. Anxiety was considered

positive if the participant responded ‘yes’ to the following two yes/no items: “Have you ever in your life had an anxiety attack — suddenly feeling fear or panic?” and “Have you had an anxiety attack in the last 4 weeks?” (62). Depression was assessed using the 2 items: “Over the last 2 weeks, how often have you been troubled by any of the following problems: little interest or pleasure in doing things?” and “Over the last 2 weeks, how often have you been troubled by any of the following problems: feeling down, depressed or hopeless?” Each item featured a 5-point response scale (“Not at all” (0) – “Nearly every day” (3)) ( $\alpha = 0.84$ ) (62, 63).

The data on social network characteristics were acquired by having used RDS (64). This data includes connectedness to a social network of MSM, which is estimated using outdegree centrality: the number of other men that a participant successfully recruited for inclusion in the study (65). Using this operationalization, connectedness reflects a participant’s ability to successfully recruit additional participants into the study. Reports of alcohol use among members of one’s social network who also participated in the study were used to estimate social network drinking. For this study, social network drinking behavior was calculated as the proportion of a participant’s ties that screened positive as hazardous drinkers using the AUDIT-C. That value was then weighted towards the mean by the inverse proportion of the number of ties that we had data on over the maximum number of ties.

### *Statistical analyses*

The specific objectives of our analyses were to: 1) describe alcohol use and abuse among black South African MSM; 2) describe associations between individual characteristics, social network characteristics and hazardous drinking; 3) assess which characteristics are independently associated with hazardous drinking.

Tests to determine which variables were associated with hazardous drinking included t-tests for continuous and scaled variables and Chi-squared tests for dichotomous variables. All predictors explored in bivariate analyses were included in the final multivariable model. Multivariable analyses were run using logistic regression for the outcome of hazardous drinking (yes versus no). All statistical tests were 2-sided and  $p < .05$  was considered statistically significant. Statistical analyses were performed with SPSS (version 17.0; SPSS, Chicago, IL) and R (version 3.3.2; R Core Team, Vienna, Austria) software packages.

Since RDS was the recruitment method used for this sample, all analyses were adjusted using an RDS II estimator (66, 67). This approach gives greater weight to those men with a small personal network size, since those men would be less likely to be recruited into the study. Equilibrium for certain characteristics was assessed and considered to be achieved when the proportions of the dichotomized variable changed by less than .02 between waves.

## **Results**

### *Sample characteristics*

In total 480 eligible participants were recruited in 18 waves between August 2011 and January 2013. All results presented are RDS-weighted. The mean number of peers recruited by each participant was 0.7. The coupon return rate was 32% (460/1417). Among the 20 seeds, 40% were less than 24 years old, 75% had some post-secondary education, 65% had a regular income, and 90% lived in a township (versus metropolitan Tshwane). Among the entire sample, most men (57%) were less than 24 years old, 52% had some post-secondary education, 35% had a regular income, and 57% lived in a township (see Table 3.1). The study reached equilibrium on the following characteristics in the respective waves: age (wave 2), education (wave 3), income (wave 3), township status (wave 12), sexual identity (wave 3), sexual attraction (wave 3) and



HIV status (wave 2). The sample has been described previously (4, 68). The prevalence of HIV among the sample was 30% and hazardous drinking was identified as an independent risk factor for HIV infection (aOR=1.8, 95%CI=1.1-3.1,  $p<.05$ ) (4).

### *Alcohol and drug use*

Most men (86%) had consumed alcohol in their lifetime, including 77% of men who had consumed alcohol in the past year. Among men who consumed alcohol in the past year, 49% consumed mostly beer, 36% consumed mostly cider (fermented alcoholic beverage made from apples), 9% (n=33) consumed mostly wine, and a small proportion (4%) consumed mostly spirits. The majority of men mostly consumed alcohol in bars and shebeens (informal drinking establishments located in townships) (53%), although many consumed alcohol equally as often at home as they did while going out (27%) or mostly at home (20%). Most men (53%) said they commonly consumed alcohol before going out to a bar or shebeen. More than half of men (51%) reported either buying alcohol for men that they wanted to have sex with or being bought alcohol by men who wanted to have sex with them.

In response to the items that comprise the AUDIT-C: 20% of men drank twice a week or more, 29% drank 2-4 times per month, and 28% drank once a month or less. A fifth of the men (21%) reported that they have 10 or more drinks on a typical day that they are drinking, 11% have 7 to 9 drinks, 23% have 5 or 6 drinks, 17% have 3 or 4 drinks, and only 5% have 1 or 2 drinks. A quarter of men (24%) reported that they have 6 or more drinks on a single occasion weekly, 22% have 6 or more drinks on a single occasion monthly, and 22% have 6 or more drinks on a single occasion less than monthly but not never. The mean AUDIT-C score was 4.7 and the median AUDIT-C score was 4.4. More than half of the men (62%, 95%CI=56%-68%) screened positive

as hazardous drinkers. Figure 3.1 shows the distribution of these men among the recruitment threads. The study reached equilibrium on hazardous drinking after 2 waves.

In the past year, 16% of men had used drugs. Men most commonly used marijuana (15%). A few men had used poppers (<1%), cocaine (1%), crack (<1%), crystal methamphetamine (<1%), methaqualone (<1%), hallucinogens (<1%), heroin (1%), or amphetamines (3%). Because hazardous drinking was found to be the vastly predominant form of substance use among this population, it served as the focus of all further analyses.

#### *Reasons for drinking and Sex-Related Alcohol Expectancies*

Table 3.2 shows the results of how reasons for drinking and sex-related alcohol expectancies correlated with hazardous drinking. Men who screened positive as hazardous drinkers were more likely to endorse drinking for a positive affect ( $p<.001$ ), drinking to cope with negative affect ( $p<.001$ ) and drinking to enhance social interactions ( $p<.001$ ). Men who screened positive as hazardous drinkers were more likely to expect alcohol to enhance sexual experience ( $p<.001$ ), increase sexual risk taking ( $p<.001$ ) and disinhibit sexual behavior ( $p<.001$ ).

#### *Correlates of hazardous drinking*

In bivariate analyses, men who screened positive as hazardous drinkers were more likely to have a secondary education or lower ( $P=.03$ ), identify as straight or bisexual (versus gay;  $p=.01$ ), be attracted to both men and women ( $P<.001$ ), have ever received money or other incentives in return for sex ( $p<.001$ ), have been sexually abused as a child ( $p<.001$ ), have higher levels of probable anxiety ( $p<.001$ ), experience more gender dysphoria ( $p<.01$ ), and have higher levels of probable depression ( $p=<.01$ ) (see Table 1). Men who screened positive as hazardous drinkers were not more connected, on average, to this social network of MSM ( $p=.77$ ). Men who screened

positive as hazardous drinkers had a higher proportion of friends, on average, who were also hazardous drinkers ( $p < .01$ )

Table 3.3 shows the results of both unweighted and RDS-weighted multivariable analyses looking at independent correlates of hazardous drinking. The measures of association from the unweighted and RDS-weighted analyses are similar in terms of their direction and strength of association. There are multiple discrepancies in terms of achieving statistical significance.

Among RDS-weighted analyses, living in a township (versus the city of Pretoria) (aOR=1.9, 95%CI=1.2-3.1,  $p < .01$ ), more gender dysphoria (aOR=1.4, 95%CI=1.0-1.8,  $p = .03$ ), having ever received money or other incentives in return for sex (aOR=2.4, 95%CI=1.3-4.3,  $p < .01$ ), having been sexually abused as a child (aOR=2.6, 95%CI=1.1-6.4,  $p = .03$ ), having anxiety (aOR=5.4, 95%CI=1.2-24.3,  $p = .03$ ), and social network drinking behavior (aOR=5.4, 95%CI=1.2-24.3,  $p = .03$ ) were positively associated with hazardous drinking. Being sexually attracted only to men (aOR=0.3, 95%CI=0.1-0.8,  $p = .01$ ) was negatively associated with hazardous drinking.

## **Discussion**

Black South African MSM were found to have high levels of alcohol use; nearly two thirds (62%, 95%CI=56%-68%) of them screened positive as hazardous drinkers. Various factors were found to increase men's likelihood of being hazardous drinkers. Men who live in a township (versus the city of Pretoria), men with higher levels of gender dysphoria, men who had ever received money or other incentives in return for sex, men who had been sexually abused as a child, and men with anxiety were all more likely to be hazardous drinkers. Men who reported being sexually attracted only to men were less likely to be hazardous drinkers. Men whose social networks included a higher proportion of hazardous drinkers were more likely to be hazardous drinkers themselves.

The high levels of alcohol use found in the current study are comparable to what has been described in other studies conducted among black South African MSM, which focused on alcohol use as a risk factor for risk behavior (2) or HIV infection (1, 3). In one study, nearly two thirds of men reported drinking regularly, with nearly half reporting that they get drunk regularly (2). In another study, over half of men reported having 10 or more drinks in a typical day of drinking and more than three quarters of men were classified as having a drinking problem (3). In another study, nearly three quarters of men reported having sex while under the influence of alcohol (1). Substance use is a major health concern among this population, especially given its association with high risk sexual behavior (5-8) in this setting of high HIV prevalence (1, 3, 4). Despite the heavy burden of alcohol use, among these men and other African MSM populations, the authors were unable to identify any implemented interventions that have targeted alcohol use among these men or any other African MSM population (10). Clearly, this is a public health problem that merits further attention.

Men who were hazardous drinkers were more likely to endorse drinking for a positive affect, drinking for negative effect and drinking to enhance social interaction. Men who were hazardous drinkers were also more likely to expect alcohol to enhance sexual experience, increase sexual risk taking and disinhibit sexual behavior. Much of the research on reasons for drinking and sex-related alcohol expectancies indicate that drinking is more likely to have an intended effect on people that endorse these beliefs (69-73), thus suggesting that hazardous drinking additionally leads to increased sexual risk behavior.

The current project is the first to identify determinants of hazardous drinking among a sample of African MSM. Living in a township (versus metropolitan Tswane), a construct that captures the vulnerability of living in a low resource setting, was found to increase men's likelihood of being

hazardous drinkers. This risk factor has been observed as an important indicator of social vulnerability and predictor of health risk in studies conducted among black South African MSM (74-77).

Other indicators of social vulnerability were also found to increase men's likelihood of being hazardous drinkers. The relationships we observed are in accordance with what has been found among non-African MSM populations. Indicators of sexual minority stress, such as gender dysphoria, have been found to be associated with substance abuse (13, 14, 18). In this study, gender dysphoria predicted hazardous drinking while controlling for other same-sex characteristics, suggesting that there is something uniquely detrimental about these feelings that they contribute to hazardous drinking. Similar to our findings, other studies have found childhood sexual abuse (78, 79) and mental health indicators, including anxiety (13, 18), to predict substance abuse among non-African MSM populations. These findings are of heightened concern because of how these co-occurring health problems work synergistically to increase risk of HIV infection (16, 17).

Men who reported being sexually attracted to both men and women were more likely to be hazardous drinkers than men who reported sexual attraction to only men. This result was observed while controlling for other potentially more proximal psychosocial characteristics that might help explain the association, such as sexual identity confusion or internalized homophobia. Another potential explanation for this might be that local community social support networks are stronger for gay MSM than they are for bisexual MSM. Further research into the dynamics of how sexual identity contributes to risk among these men, both in terms of hazardous drinking and sexual vulnerability, is needed.

The current project is also the first to consider social network characteristics in the evaluation of substance use among a sample of African MSM. We found that the size of men's social network did not impact men's likelihood of being a hazardous drinker, although the drinking behavior of their social network members did. This finding speaks to the importance of the characteristics of social network ties because they provide a context for behavior and norms (30, 80-82), more than concern for the presence of social network ties in themselves (i.e. being connected versus isolated) (29, 34, 83). This is an area that merits further exploration, particularly given the heightened importance of social networks in this setting (37) and their potential as conduits for an intervention (84).

There are certain limitations to the current study. The cross-sectional research design limits the ability to infer causality. For example, we assume that the drinking behaviors of one's social network members influences one's own drinking behavior. However, these findings may also reflect that men who drink more tend to befriend other men who drink more. The social network data used in the study was limited to recruitment information collected routinely as part of the application of RDS. The social network data available could be considered sociocentric in that multiple members of men's social networks were interviewed; however the study did not utilize a social network design and thus much information about these men's social networks is missing. For instance, we do not know about connections between men other than the ones who recruited each other. Also, we did not collect any information about the nature of the relationships between men, including if they were sexual partners. The measures that we did estimate, such as connectedness (outdegree centrality), reflects a participant's ability to successfully recruit additional participants into the study as much as it likely reflects their actual connectedness to other MSM in Tshwane. There were also certain findings that were not in agreement with our

expectations. For example, it is not clear why being sexually attracted only to men decreased men's likelihood of being a hazardous drinker when in previous research this was found to predict alcohol dependence (13). Furthermore, some potential risk factors were not found to be associated with hazardous drinking. This likely speaks to the exploratory nature of this study, given the lack of previous research among African MSM populations, as well as the complexity of substance use and psychosocial health among men in this setting (4, 85, 86). These issues merit further exploration. The outcome measure, hazardous drinking, as assessed by the AUDIT-C, was chosen because hazardous drinking is of concern in this context of high HIV prevalence, particularly as heavy alcohol consumption, or binge drinking, might increase risky sexual behavior. Using the AUDIT-C criteria to identify hazardous drinkers, though, could include regular, moderate drinkers. Further analyses are warranted that explore different operationalizations of alcohol use and the prevalence of binge drinking, as well as dependent drinking. Unfortunately, the study did not collect information on being on treatment for HIV. Given how few men knew their current HIV status, the limited availability of antiretroviral therapy (ART) during the study period and the criteria for starting treatment at the time, we suspect that few men were on ART. The mental health measures, anxiety and depression, were limited to 2 brief screening questions each and are not robust measures of psychiatric disorder. The current study was conducted among black South African MSM and may have limited generalizability outside of that setting. The constructs used were almost exclusively developed in Western settings, and while many of them have previously been demonstrated to be reliable and valid, including many in South Africa, there may be additional culture-specific factors that have not been accounted for. Lastly, the data collected are self-reported and could have been subject to social desirability or recall bias.

In summary, the current study expands the literature by providing further evidence of the severity of excessive alcohol use among black South African MSM. Various determinants of hazardous drinking were identified, including many indicators of social vulnerability. The findings are of concern because these health problems often work synergistically to increase risk of HIV infection. The drinking habits of men's social network ties also was highly correlated with men's own drinking habits. These findings should be taken into consideration by efforts aimed at reducing hazardous drinking among this critical population. Specifically, intervention strategies should consider targeting MSM who are the most vulnerable, those who live in townships, who have had to engage in sex for money or favors, who have a history of childhood sexual abuse or who suffer from other mental health problems. Possible interventions might include those that not only target individuals but their social networks (87) . Efforts aimed at reducing hazardous drinking are greatly needed. Specifically, interventions that use social network data to reduce hazardous drinking appear to be warranted (88). Network interventions include opinion leader interventions (89-91), where influential members of a social network are used to disseminate behavior change messages, or using other more strategically located members to diffuse behavior change messages through a social network (92). When considering social network approaches to designing an intervention, it is important to note that social network interventions are not a one-size-fits-all model, but that they depend on the goals and objectives for that intervention (88).



## Figures

Figure 3.1. Distribution of hazardous drinkers among networks, with 3 distinct network chains extracted.



## Tables

Table 3.1. Characteristics of MSM by hazardous drinking

	Total		Hazardous drinking		No hazardous drinking		X <sup>2</sup>	P
	N	(%)	N	(%)	N	(%)		
<b>Demographic characteristics</b>								
Age							0.3	0.61
23 or younger	272	57%	171	63%	101	37%		
24 or older	208	43%	126	61%	82	39%		
Education							4.5	0.03
Secondary or lower	229	48%	153	67%	76	33%		
Post secondary	251	52%	144	57%	107	43%		
Regular income							0.0	0.97
No	311	65%	192	62%	119	38%		
Yes	168	35%	104	62%	64	38%		
Living in a township							10.2	0.00
No	204	43%	109	53%	95	47%		
Yes	274	57%	186	68%	88	32%		
<b>Psychosocial factors (dichotomous)</b>								
Sexual identification							6.7	0.01
Gay or transgender	332	70%	192	58%	140	42%		
Bisexual or straight	145	30%	102	70%	43	30%		
Sexual attraction							17.5	<.001
Only attracted to men	320	67%	177	55%	143	45%		
Also attracted to women	160	33%	120	75%	40	25%		
Ever received money or incentives for sex							18.5	<.001
No	369	77%	209	57%	160	43%		
Yes	111	23%	88	79%	23	21%		
Sexually abused as a child							12.2	<.001
No	429	89%	254	59%	175	41%		
Yes	51	11%	43	84%	8	16%		

	Total		Hazardous drinking		No hazardous drinking			
Anxiety							17.4	<.001
No	431	89%	253	59%	178	41%		
Yes	51	11%	43	84%	8	16%		
<b>Psychosocial factors (continuous)<sup>1</sup></b>	mean	SD	mean	SD	mean	SD	t	P
Femininity <sup>2</sup>	2.9	1.1	2.9	1.1	3.0	1.0	0.7	0.47
Sexual identify confusion <sup>3</sup>	2.0	0.6	2.1	0.6	2.0	0.5	-1.6	0.12
Secretiveness about sexuality <sup>3</sup>	2.2	0.9	2.2	0.9	2.2	0.9	0.1	0.92
Internalized homophobia <sup>2</sup>	2.1	0.5	2.2	0.5	2.1	0.5	-1.2	0.24
Gender dysphoria <sup>4</sup>	0.7	1.0	0.8	1.1	0.5	0.9	-2.9	0.00
Sexual orientation-based discrimination <sup>3</sup>	1.5	0.6	1.5	0.6	1.5	0.5	-1.6	0.10
Depression <sup>3</sup>	1.5	0.7	1.6	0.8	1.4	0.6	-2.6	0.01
<b>Social network characteristics<sup>1</sup></b>								
Social network connectedness <sup>5</sup>	0.7	1.1	0.7	1.1	0.8	1.1	0.3	0.77
Social network drinking behavior <sup>6</sup>	0.6	0.1	0.7	0.1	0.6	0.2	-3.9	<.001

1. Higher scores indicate higher levels of the construct; 2. Range 1-5; 3. Range 1-4; 4. Range 0-4; 5. Range 0-5; 6. Range 0-1.

Table 3.2. Reasons for drinking, sex-related alcohol expectancies by hazardous drinking

	Total		Hazardous drinking		No hazardous drinking		t	P
	mean	SD	mean	SD	mean	SD		
<b>Reasons for drinking</b>								
Drinking for positive affect	2.5	1.2	3.1	0.9	1.5	0.8	-19.5	<.001
Drinking for negative affect	2.1	1.1	2.5	1.1	1.4	0.7	-12.5	<.001
Drinking to enhance social interactions	2.4	1.2	2.9	1.1	1.5	0.9	-14.9	<.001
All reasons for drinking	2.3	1.1	2.8	0.9	1.5	0.8	-17.0	<.001
<b>Sex-related alcohol expectancies</b>								
Enhancement of sexual experience	2.6	0.6	2.7	0.5	2.4	0.7	-6.0	<.001
Increased sexual risk taking	2.3	0.6	2.4	0.5	2.2	0.7	-3.4	<.001
Disinhibition of sexual behavior	2.3	0.6	2.4	0.5	2.1	0.7	-5.9	<.001
All sex-related alcohol expectancies	2.4	0.6	2.3	0.6	2.5	0.4	-5.6	<.001

Table 3.3. Risk factors for hazardous drinking, unweighted and RDS-weighted

	Unweighted			RDS-weighted		
	aOR	95% CI	P	aOR	95% CI	P
<b>Demographic characteristics</b>						
Older than 24	0.7	0.5 – 1.1	0.16	0.7	0.4 – 1.1	0.12
Post secondary education	1.0	0.7 – 1.6	0.85	0.9	0.5 – 1.3	0.48
Has a regular income	1.4	0.9 – 2.1	0.21	1.2	0.7 – 1.9	0.53
Living in a township	1.5	1.0 – 2.4	0.07	1.9	1.2 – 3.1	<0.01
<b>Psychosocial factors<sup>1</sup></b>						
Identify as gay or transgender	1.2	0.5 – 2.9	0.62	1.4	0.5 – 3.6	0.49
Only sexually attracted to men	0.5	0.2 – 1.0	0.05	0.3	0.1 – 0.8	0.01
Femininity <sup>2</sup>	0.8	0.6 – 1.0	0.06	0.8	0.6 – 1.1	0.14
Sexual identify confusion <sup>3</sup>	1.1	0.7 – 1.7	0.63	1.1	0.7 – 1.7	0.80
Secretiveness about sexuality <sup>3</sup>	1.1	0.8 – 1.5	0.75	0.9	0.7 – 1.3	0.64
Internalized homophobia <sup>2</sup>	0.7	0.4 – 1.2	0.23	1.1	0.6 – 1.9	0.85
Gender dysphoria <sup>4</sup>	1.2	0.9 – 1.6	0.13	1.4	1.0 – 1.8	0.03
Sexual orientation-based discrimination <sup>3</sup>	0.9	0.6 – 1.4	0.61	0.8	0.5 – 1.2	0.31
Ever received money or incentives for sex	2.7	1.5 – 4.9	<0.01	2.4	1.3 – 4.3	<0.01
Sexually abused as a child	2.0	1.1 – 7.7	0.08	2.7	1.1 – 6.5	0.03
Anxiety	2.9	1.1 – 7.7	0.04	6.1	2.1 – 17.3	0.00
Depression <sup>3</sup>	1.1	0.7 – 1.5	0.76	1.0	0.7 – 1.5	0.91
<b>Social network characteristics<sup>1</sup></b>						
Social network connectedness <sup>5</sup>	1.1	0.9 – 1.3	0.28	1.1	0.9 – 1.3	0.41
Social network drinking behavior <sup>6</sup>	3.9	1.0 – 16.0	0.06	5.4	1.2 – 24.3	0.03

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1. Higher scores indicate higher levels of the construct; 2. Range 1-5; 3. Range 1-4; 4. Range 0-4; 5. Range 0-5; 6. Range 0-1.

## References

1. Rispel LC, Metcalf CA, Cloete A, Reddy V, Lombard C. HIV prevalence and risk practices among men who have sex with men in two South African cities. *J Acquir Immune Defic Syndr*. 2011;57(1):69-76.
2. Lane T, Shade SB, McIntyre J, Morin SF. Alcohol and sexual risk behavior among men who have sex with men in South african township communities. *AIDS Behav*. 2008;12(4 Suppl):S78-85.
3. Lane T, Raymond HF, Dladla S, Rasethe J, Struthers H, McFarland W, et al. High HIV prevalence among men who have sex with men in Soweto, South Africa: results from the Soweto Men's Study. *AIDS Behav*. 2011;15(3):626-34.
4. Sandfort TG, Lane T, Dolezal C, Reddy V. Gender expression and risk of HIV infection among black South African men who have sex with men. *AIDS Behav*. 2015;19(12):2270-9.
5. Rehm J, Shield KD, Joharchi N, Shuper PA. Alcohol consumption and the intention to engage in unprotected sex: systematic review and meta-analysis of experimental studies. *Addiction (Abingdon, England)*. 2012;107(1):51-9.
6. Kalichman SC, Simbayi LC, Kaufman M, Cain D, Jooste S. Alcohol use and sexual risks for HIV/AIDS in sub-Saharan Africa: Systematic review of empirical findings. *Prev Sci*. 2007;8(2):141-51.
7. Bryant KJ. Expanding research on the role of alcohol consumption and related risks in the prevention and treatment of HIV/AIDS. *Substance use & misuse*. 2006;41(10-12):1465-507.
8. Woolf-King SE, Maisto SA. Alcohol use and high-risk sexual behavior in Sub-Saharan Africa: a narrative review. *Archives of sexual behavior*. 2011;40(1):17-42.
9. Williams EC, Hahn JA, Saitz R, Bryant K, Lira MC, Samet JH. Alcohol use and Human Immunodeficiency Virus (HIV) infection: current knowledge, implications, and future directions. *Alcoholism, clinical and experimental research*. 2016;40(10):2056-72.
10. Sandfort T, Knox J, Alcalá C, El-Bassel N, Kuo I, Smith L. Substance use and HIV risk among men who have sex with men in Africa: A systematic review. *J Acquir Immune Defic Syndr*. In Press.
11. Sandfort TG, de Graaf R, Bijl RV, Schnabel P. Same-sex sexual behavior and psychiatric disorders: findings from the Netherlands Mental Health Survey and Incidence Study (NEMESIS). *Arch Gen Psychiatry*. 2001;58(1):85-91.
12. Sandfort TG, de Graaf R, Ten Have M, Ransome Y, Schnabel P. Same-sex sexuality and psychiatric disorders in the second Netherlands Mental Health Survey and Incidence Study (NEMESIS-2). *LGBT Health*. 2014;1(4):292-301.
13. Stall R, Paul JP, Greenwood G, Pollack LM, Bein E, Crosby GM, et al. Alcohol use, drug use and alcohol-related problems among men who have sex with men: the Urban Men's Health Study. *Addiction (Abingdon, England)*. 2001;96(11):1589-601.
14. McKirnan DJ, Peterson PL. Psychosocial and cultural factors in alcohol and drug abuse: an analysis of a homosexual community. *Addictive behaviors*. 1989;14(5):555-63.
15. McKirnan DJ, Peterson PL. Alcohol and drug use among homosexual men and women: epidemiology and population characteristics. *Addictive behaviors*. 1989;14(5):545-53.

16. Stall R, Mills TC, Williamson J, Hart T, Greenwood G, Paul J, et al. Association of co-occurring psychosocial health problems and increased vulnerability to HIV/AIDS among urban men who have sex with men. *Am J Public Health*. 2003;93(6):939-42.
17. Jie W, Ciyong L, Xueqing D, Hui W, Lingyao H. A syndemic of psychosocial problems places the MSM (men who have sex with men) population at greater risk of HIV infection. *PloS one*. 2012;7(3):e32312.
18. Rosario M, Schrimshaw EW, Hunter J. A model of sexual risk behaviors among young gay and bisexual men: longitudinal associations of mental health, substance abuse, sexual abuse, and the coming-out process. *AIDS education and prevention : official publication of the International Society for AIDS Education*. 2006;18(5):444-60.
19. Wang J, Hausermann M, Ajdacic-Gross V, Aggleton P, Weiss MG. High prevalence of mental disorders and comorbidity in the Geneva Gay Men's Health Study. *Social psychiatry and psychiatric epidemiology*. 2007;42(5):414-20.
20. Niang CI, Tapsoba P, Weiss E, Diagne M, Niang Y, Moreau AM, et al. 'It's raining stones': stigma, violence and HIV vulnerability among men who have sex with men in Dakar, Senegal. *Cult Health Sex*. 2003;5(6):499-512.
21. van Griensven F. Men who have sex with men and their HIV epidemics in Africa. *AIDS*. 2007;21(10):1361-2 10.097/QAD.0b013e328017f868.
22. van Griensven F, Sanders EJ. Understanding HIV risks among men who have sex with men in Africa. *Sexually Transmitted Diseases*. 2008;35(4):355-6.
23. Smith AD, Tapsoba P, Peshu N, Sanders EJ, Jaffe HW. Men who have sex with men and HIV/AIDS in sub-Saharan Africa. *Lancet*. 2009;374(9687):416-22.
24. Adam PCG, de Wit JBE, Toskin I, Mathers BM, Nashkoev M, Zablotska I, et al. Estimating levels of HIV testing, HIV prevention coverage, HIV knowledge, and condom use among men who have sex with men (MSM) in low-income and middle-income countries. *J Acquir Immune Defic Syndr*. 2009;52:S143-S51.
25. Muraguri N, Temmerman M, Geibel S. A decade of research involving men who have sex with men in sub-Saharan Africa: current knowledge and future directions. *SAHARA J*. 2012;9(3):137-47.
26. Smith KP, Christakis NA. Social networks and health. *Annu Rev Sociol*. 2008;34:405-29.
27. Umberson D, Montez JK. Social relationships and health: A flashpoint for health policy. *J Health Soc Behav*. 2010;51:S54-S66.
28. Friedman SR, Aral S. Social networks, risk-potential networks, health, and disease. *Journal of Urban Health*. 2001;78(3):411-8.
29. Smith AMA, Grierson J, Wain D, Pitts M, Pattison P. Associations between the sexual behaviour of men who have sex with men and the structure and composition of their social networks. *Sexually transmitted infections*. 2004;80(6):455-8.
30. Luke DA, Harris JK. Network analysis in public health: History, methods, and applications. *Annu Rev Publ Health*. 2007;28:69-93.
31. Youm Y, Laumann EO. Social network effects on the transmission of sexually transmitted diseases. *Sexually Transmitted Diseases*. 2002;29(11):689-97.
32. Doherty IA, Padian NS, Marlow C, Aral SO. Determinants and consequences of sexual networks as they affect the spread of sexually transmitted infections. *Journal of Infectious Diseases*. 2005;191:S42-S54.
33. Valente TW. Social network influences on adolescent substance use: an introduction. *Connections*. 2003;25(2):11-6.

34. Alexander C, Piazza M, Mekos D, Valente T. Peers, schools, and adolescent cigarette smoking. *The Journal of adolescent health : official publication of the Society for Adolescent Medicine*. 2001;29(1):22-30.
35. Windle M. Parental, sibling, and peer influences on adolescent substance use and alcohol problems. *Appl Dev Sci*. 2000;4:98-110.
36. Gaughan M. Predisposition and pressure: mutual influence and adolescent drunkenness. *Connections*. 2003;25(2):17-31.
37. Latkin CA, Davey-Rothwell MA, Knowlton AR, Alexander KA, Williams CT, Boodram B. Social network approaches to recruitment, HIV prevention, medical care, and medication adherence. *J Acquir Immune Defic Syndr*. 2013;63 Suppl 1:S54-8.
38. Rabie F, Lesch E. 'I am like a woman': constructions of sexuality among gay men in a low-income South African community. *Cult Health Sex*. 2009;11(7):717-29.
39. Magnani R, Sabin K, Saidel T, Heckathorn D. Review of sampling hard-to-reach and hidden populations for HIV surveillance. *AIDS*. 2005;19 Suppl 2:S67-72.
40. Heckathorn DD. Respondent-driven sampling: A new approach to the study of hidden populations. *Social Problems*. 1997;44(2):174-99.
41. Heckathorn DD, Semaan S, Broadhead RS, Hughes JJ. Extensions of respondent-driven sampling: A new approach to the study of injection drug users aged 18-25. *Aids Behav*. 2002;6(1):55-67.
42. Heath DB. Uses and Misuses of the Concept of Ethnicity in Alcohol Studies - an Essay in Deconstruction. *Int J Addict*. 1991;25(5A-6A):607-28.
43. Heath AC, Martin NG. The inheritance of alcohol sensitivity and of patterns of alcohol use. *Alcohol and alcoholism*. 1991;1:141-5.
44. Saunders JB, Aasland OG, Babor TF, de la Fuente JR, Grant M. Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO Collaborative Project on Early Detection of Persons with Harmful Alcohol Consumption--II. *Addiction (Abingdon, England)*. 1993;88(6):791-804.
45. Bohn MJ, Babor TF, Kranzler HR. The Alcohol Use Disorders Identification Test (AUDIT): validation of a screening instrument for use in medical settings. *Journal of studies on alcohol*. 1995;56(4):423-32.
46. Myer L, Smit J, Roux LL, Parker S, Stein DJ, Seedat S. Common mental disorders among HIV-infected individuals in South Africa: prevalence, predictors, and validation of brief psychiatric rating scales. *AIDS patient care and STDs*. 2008;22(2):147-58.
47. Jewkes R, Nduna M, Levin J, Jama N, Dunkle K, Khuzwayo N, et al. A cluster randomized-controlled trial to determine the effectiveness of Stepping Stones in preventing HIV infections and promoting safer sexual behaviour amongst youth in the rural Eastern Cape, South Africa: trial design, methods and baseline findings. *Tropical medicine & international health : TM & IH*. 2006;11(1):3-16.
48. Peltzer K, Seoka P, Babor T, Obot I. Training primary care nurses to conduct alcohol screening and brief interventions in South Africa. *Curationis*. 2006;29(2):16-21.
49. Peltzer K, Davids A, Njuho P. Alcohol use and problem drinking in South Africa: findings from a national population-based survey. *African journal of psychiatry*. 2011;14(1):30-7.
50. Bush K, Kivlahan DR, McDonell MB, Fihn SD, Bradley KA. The AUDIT alcohol consumption questions (AUDIT-C): an effective brief screening test for problem drinking. *Archives of internal medicine*. 1998;158(16):1789-95.



51. Golding JM, Burnam MA, Benjamin B, Wells KB. Reasons for drinking, alcohol use, and alcoholism among Mexican Americans and non-Hispanic Whites. *Psychol Addict Behav.* 1992;6(3):155-67.
52. Dermen KH, Cooper ML. Sex-related alcohol expectancies among adolescents: I. Scale development. *Psychol Addict Behav.* 1994;8(3):152-60.
53. Dermen KH, Cooper ML. Sex-related alcohol expectancies among adolescents: II. Prediction of drinking in social and sexual situations. *Psychol Addict Behav.* 1994;8(3):161-8.
54. Morojele NK, Kachieng'a MA, Mokoko E, Nkoko MA, Parry CD, Nkowane AM, et al. Alcohol use and sexual behaviour among risky drinkers and bar and shebeen patrons in Gauteng province, South Africa. *Social science & medicine.* 2006;62(1):217-27.
55. Kalichman SC, Simbayi LC. Sexual assault history and risks for sexually transmitted infections among women in an African township in Cape Town, South Africa. *AIDS care.* 2004;16(6):681-9.
56. Storms MD. Sex-Role Identity and Its Relationships to Sex-Role Attributes and Sex-Role Stereotypes. *J Pers Soc Psychol.* 1979;37(10):1779-89.
57. Mohr JJ, Fassinger RE. Measuring dimensions of lesbian and gay male experience. *Meas Eval Couns Dev.* 2000;33:66-90.
58. Mohr JJ, Fassinger RE. Sexual orientation identity and romantic relationship quality in same-sex couples. *Pers Soc Psychol Bull.* 2006;32(8):1085-99.
59. Day NE, Schoenrade P. Staying in the closet versus coming out: relationships between communication about sexual orientation and work attitudes. *Pers Psychol.* 1997;50(1):147-63.
60. Singh D, Deogracias JJ, Johnson LL, Bradley SJ, Kibblewhite SJ, Owen-Anderson A, et al. The Gender Identity/Gender Dysphoria Questionnaire for Adolescents and Adults: Further Validity Evidence. *J Sex Res.* 2010;47(1):49-58.
61. Deogracias JJ, Johnson LL, Meyer-Bahlburg HFL, Kessler SJ, Schober JM, Zucker KJ. The gender identity/gender dysphoria questionnaire for adolescents and adults. *J Sex Res.* 2007;44(4):370-9.
62. Kroenke K, Spitzer RL, Williams JBW, Lowe B. The Patient Health Questionnaire Somatic, Anxiety, and Depressive Symptom Scales: a systematic review. *Gen Hosp Psychiat.* 2010;32(4):345-59.
63. Kroenke K, Spitzer RL, Williams JBW. The Patient Health Questionnaire-2 - Validity of a two-item depression screener. *Med Care.* 2003;41(11):1284-92.
64. Wejnert C. Social network analysis with respondent-driven sampling data: a study of racial integration on campus. *Social networks.* 2010;32(2):112-24.
65. Valente TW, Gallaher P, Mouttapa M. Using social networks to understand and prevent substance use: a transdisciplinary perspective. *Substance use & misuse.* 2004;39(10-12):1685-712.
66. Volz E, Heckathorn DD. Probability based estimation theory for respondent driven sampling. *J Off Stat.* 2008;24(1):79-97.
67. Salganik MJ, Heckathorn DD. Sampling and estimation in hidden populations using respondent driven sampling. *Sociol Methodol.* 2004;34(1):193-240.
68. Knox J, Reddy V, Lane T, Hasin D, Sandfort T. Substance Use and Sexual Risk Behavior Among Black South African Men Who Have Sex With Men: The Moderating Effects of Reasons for Drinking and Safer Sex Intentions. *AIDS and behavior.* 2017;21(7):2023-32.

69. Dermen KH, Cooper ML, Agocha VB. Sex-related alcohol expectancies as moderators of the relationship between alcohol use and risky sex in adolescents. *Journal of studies on alcohol*. 1998;59(1):71-7.
70. Bryan AD, Ray LA, Cooper ML. Alcohol use and protective sexual behaviors among high-risk adolescents. *J Stud Alcohol Drugs*. 2007;68(3):327-35.
71. McKirnan DJ, Vanable PA, Ostrow DG, Hope B. Expectancies of sexual "escape" and sexual risk among drug and alcohol-involved gay and bisexual men. *Journal of substance abuse*. 2001;13(1-2):137-54.
72. Fromme K, D'Amico EJ, Katz EC. Intoxicated sexual risk taking: an expectancy or cognitive impairment explanation? *Journal of studies on alcohol*. 1999;60(1):54-63.
73. Gordon CM, Carey MP, Carey KB. Effects of a drinking event on behavioral skills and condom attitudes in men: implications for HIV risk from a controlled experiment. *Health Psychol*. 1997;16(5):490-5.
74. Knox J, Reddy V, Kaighobadi F, Nel D, Sandfort T. Communicating HIV status in sexual interactions: assessing social cognitive constructs, situational factors, and individual characteristics among South African MSM. *AIDS Behav*. 2013;17(1):350-9.
75. Knox J, Yi H, Reddy V, Maimane S, Sandfort T. The fallacy of intimacy: sexual risk behaviour and beliefs about trust and condom use among men who have sex with men in South Africa. *Psychol Health Med*. 2010;15(6):660-71.
76. Sandfort T, Yi H, Knox J, Reddy V. Sexual partnership types as determinant of HIV risk in South African MSM: an event-level cluster analysis. *AIDS Behav*. 2013;17 Suppl 1:S23-32.
77. Knox J, Sandfort T, Yi H, Reddy V, Maimane S. Social vulnerability and HIV testing among South African men who have sex with men. *Int J STD AIDS*. 2011:709-13.
78. Diaz RM, Morales ES, Bein E, Dilan E, Rodriguez RA. Predictors of sexual risk in latino gay/bisexual men: the role of demographic, developmental, social cognitive, and behavioral variables. *Hisp J Behav Sci*. 1999;21(4):480-501.
79. Paul JP, Catania J, Pollack L, Stall R. Understanding childhood sexual abuse as a predictor of sexual risk-taking among men who have sex with men: The Urban Men's Health Study. *Child abuse & neglect*. 2001;25(4):557-84.
80. Latkin C, Donnell D, Celentano DD, Aramrattna A, Liu TY, Vongchak T, et al. Relationships between social norms, social network characteristics, and HIV risk behaviors in Thailand and the United States. *Health Psychol*. 2009;28(3):323-9.
81. Friedman SR, Bolyard M, Mateu-Gelabert P, Goltzman P, Pawlowicz MP, Singh DZ, et al. Some data-driven reflections on priorities in AIDS network research. *AIDS Behav*. 2007;11(5):641-51.
82. Valente TW, Fosados R. Diffusion of innovations and network segmentation: The part played by people in promoting health. *Sexually Transmitted Diseases*. 2006;33(7):S23-S31.
83. HELLERINGER S, KOHLER HP. Sexual network structure and the spread of HIV in Africa: evidence from Likoma Island, Malawi. *Aids*. 2007;21(17):2323-32.
84. Latkin CA. Outreach in natural settings: the use of peer leaders for HIV prevention among injecting drug users' networks. *Public health reports*. 1998;113 Suppl 1:151-9.
85. Cook SH, Sandfort TG, Nel JA, Rich EP. Exploring the relationship between gender nonconformity and mental health among black South african gay and bisexual men. *Archives of sexual behavior*. 2013;42(3):327-30.

86. Sandfort T, Bos H, Knox J, Reddy V. Gender nonconformity, discrimination, and mental health among black South African men who have sex with men: a further exploration of unexpected findings. *Archives of sexual behavior*. 2016;45(3):661-70.
87. Copello A, Orfor J, Hodgson R, Tober G, Barrett C, Trial URTUKAT. Social behaviour and network therapy basic principles and early experiences. *Addictive behaviors*. 2002;27(3):345-66.

## Appendix

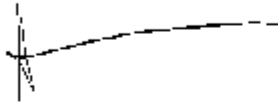
October 31, 2017

To whom this may concern:

The papers submitted for Justin Knox's dissertation reflect his own work prior to any editorial input from either of us as co-authors.

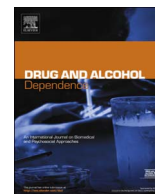
Sincerely,

Theo Sandfort

A handwritten signature in black ink, appearing to read 'Theo Sandfort'. The signature is written in a cursive style with a long horizontal stroke extending to the right.

Deborah Hasin

A handwritten signature in black ink, appearing to read 'Deborah Hasin'. The signature is written in a cursive style.



## Full length article

# Determinants of hazardous drinking among black South African men who have sex with men

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## ABSTRACT

**Background:** There is a known heavy burden of hazardous drinking and its associated health risks among black South African MSM; however, no study to date has identified risk factors for hazardous drinking among this nor any other African MSM population.

**Methods:** A cross-sectional survey was conducted among 480 black South African MSM recruited using respondent-driven sampling. All analyses were adjusted using an RDS II estimator. Multivariable logistic regression was used to assess the relationship between demographic characteristics, psychosocial factors, behavioral attributes and hazardous drinking.

**Results:** More than half of the men (62%, 95%CI = 56%–68%) screened positive as hazardous drinkers. In multivariable analyses, living in a township (versus the city of Pretoria) (aOR = 1.9, 95%CI = 1.2–3.1,  $p < .01$ ), more gender dysphoria (aOR = 1.4, 95%CI = 1.0–1.8,  $p = .03$ ), having ever received money or other incentives in return for sex (aOR = 2.4, 95%CI = 1.3–4.3,  $p < .01$ ), having been sexually abused as a child (aOR = 2.6, 95%CI = 1.1–6.4,  $p = .03$ ), having anxiety (aOR = 5.4, 95%CI = 1.2–24.3,  $p = .03$ ), and social network drinking behavior (aOR = 5.4, 95%CI = 1.2–24.3,  $p = .03$ ) were positively associated with hazardous drinking. Being sexually attracted only to men (aOR = 0.3, 95%CI = 0.1–0.8,  $p = .01$ ) was negatively associated with hazardous drinking.

**Discussion:** Hazardous drinking is highly prevalent among black South African MSM. Multiple indicators of social vulnerability were identified as independent determinants of hazardous drinking. These findings are of heightened concern because these health problems often work synergistically to increase risk of HIV infection and should be taken into consideration by efforts aimed at reducing hazardous drinking among this critical population.

## 1. Introduction

Black South African men who have sex with men (MSM) consume high levels of alcohol (Lane et al., 2011, 2008; Rispel et al., 2011). In one study, nearly two thirds of men reported drinking regularly, with nearly half reporting that they get drunk regularly (Lane et al., 2008). In another study, over half of men reported having 10 or more drinks in a typical day of drinking and more than three quarters of men were classified as having a drinking problem (Lane et al., 2011). In another study, nearly three quarters of men reported having sex while under the influence of alcohol (Rispel et al., 2011). Alcohol use and abuse constitutes a major public health problem, contributing to injury, disease

and death. Hazardous drinking is of particular concern among this population due to the high prevalence of HIV, which estimates range between 13% and 50% (Lane et al., 2011; Rispel et al., 2011; Sandfort et al., 2015), and the increased risk of HIV infection associated with excessive drinking (Bryant, 2006; Kalichman et al., 2007; Rehm et al., 2012; Woolf-King and Maisto, 2011). Alcohol use has also been shown to have negative health consequences among people living with HIV, including lack of viral suppression, common comorbid conditions, and ultimately morbidity and mortality through both biological and behavioral mechanisms (Williams et al., 2016). Despite the known burden of hazardous drinking and its associated health risks, no study to date has identified risk factors for hazardous drinking among black South

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African MSM, nor any other African MSM population (Sandfort et al., in press).

Researchers have observed elevated rates of concurrent psychosocial problems, including heavy alcohol use, among non-African LGBT populations (McKirnan and Peterson, 1989a,b; Sandfort et al., 2001, 2014; Stall et al., 2003, 2001), noting that they work synergistically to increase risk of HIV infection (Jie et al., 2012; Stall et al., 2003). For example, mental health problems, including anxiety (Rosario et al., 2006), and depression (Wang et al., 2007), often co-occur with substance use disorders, particularly alcohol dependence (Stall et al., 2001). Sexual minority stressors, such as internalized homophobia and external homophobia (i.e., experiences with sexual orientation-related discrimination), are associated with increased alcohol-related problems (McKirnan and Peterson, 1989b; Stall et al., 2001), and are likely of heightened importance among black South African MSM where same-sex sexuality is highly stigmatized (Adam et al., 2009; Muraguri et al., 2012; Niang et al., 2003; Smith et al., 2009; van Griensven, 2007; van Griensven and Sanders, 2008). Social network characteristics are also potential determinants of hazardous drinking as social networks are known to play a major role in many health-related behaviors (Doherty et al., 2005; Friedman and Aral, 2001; Luke and Harris, 2007; Smith et al., 2004; Smith and Christakis, 2008; Umberson and Montez, 2010; Youm and Laumann, 2002). For example, the drinking behavior of an individual's social network members often provides a crucial context for individual decisions on how much and how often to drink (Valente, 2003). One's degree of connectedness to a specific social network has been found to be positively associated with one's likelihood of reflecting the normative behavior of that group regarding substance use (Alexander et al., 2001). Peers' alcohol use has been found to be a primary influence on an individual's alcohol use (Gaughan, 2003; Windle, 2000). There is also a potential heightened importance of social networks among stigmatized populations, such as black South African MSM (Latkin et al., 2013).

This paper aims to describe alcohol use among black South African MSM and identify determinants that put them at risk for hazardous drinking. The data for this project were collected among black MSM living in Tshwane, South Africa. These men currently live in or have recently moved from township communities. Township communities are peri-urban areas (the landscape interface between town and country) previously segregated under Apartheid whose residents continue to be characterized by limited resources, low levels of education, and high rates of unemployment. Personal social networks are the primary context in which these men learn how to express their sexuality, deal with stigma, and manage the risks of unprotected sex (Rabie and Lesch, 2009). They meet potential sex partners predominantly through these social networks or at drinking establishments. These circumstances combine to create a context where substance use, particularly excessive substance use, is normative (Lane et al., 2008; Rispel et al., 2011; Sandfort et al., 2015). Respondent-driven sampling (RDS) was chosen as the method to recruit these men because it is the most reliable way to derive valid population estimates for hidden populations such as black South African MSM (Magnani et al., 2005).

## 2. Materials and methods

### 2.1. Study population and procedures

The data used for the current project was collected as part of a study whose primary objective was to determine the prevalence of HIV infection among black MSM in Tshwane (Sandfort et al., 2015). Participants were recruited using RDS (Heckathorn, 1997; Heckathorn et al., 2002). Eligibility criteria for study participation included age older than 18; having engaged in oral, anal, or masturbatory sex with another man in the prior 12 months; living, working, or socializing in the Tshwane metro area; fluency in English, Sepedi (Northern Sotho), or isiZulu; and willingness to take an HIV rapid test. Consistent with RDS

methodology, seeds, 20 in total, distributed up to five coupons to eligible men from their social networks who they were willing to recruit into the study. The seeds were referred by the community advisory board, screened to ensure that they met all of the study eligibility criteria and then interviewed about their social network size and composition. All seeds were Black and were purposively selected based on geographic place of residence in the Tshwane metro area and age. Men enrolled in the study and completed study procedures, including a 90-min interviewer-administered computer-assisted personal interview and an HIV blood test, which was conducted following a serial algorithm in accordance with South African national guidelines. All participants were screened by licensed nurses using two licensed rapid test kits (EZ Trust HIV 1 and 2, CS Innovation; First Response, Premier Medical Corporation). Non-reactive samples were interpreted as negative. Samples that were reactive on both tests were confirmed as positive. There were no indeterminate results. Staff provided participants with up to five recruitment coupons for further distribution. All study participants received vouchers worth 150 South African Rand (~\$12 US Dollars) to be redeemed at a supermarket as primary incentive for their own participation, as well as additional vouchers worth 50 South African Rand (~\$4 US Dollars) as secondary incentives for each successful referral to the study. At one point, verification of the inclusion criteria was expanded in order to ensure that all participants met the inclusion criteria. We did not observe evidence of anything else that might have threatened the integrity of the recruitment process. Participants were linked to their referral chain using their coupon identification numbers. All study procedures were approved by the Institutional Review Board of the New York State Psychiatric Institute in the U.S. and the Research Ethics Committee of the Human Sciences Research Council in South Africa. Participants provided written informed consent for the survey. Study staff provided referrals for further HIV testing and counseling, mental health, or primary care as indicated.

### 2.2. Measures

Scales adapted for and previously validated in South Africa were used whenever possible. Multiple aspects of alcohol use practices were evaluated (Heath and Martin, 1991; Heath, 1991). First, men were asked if they ever drank alcohol, then if they drank alcohol in the past year. Men replied 'yes' or 'no'. They were then asked where they drink and what they drink. They were also asked if they drink before going out, if they pay for their own drinks, if they buy drinks for men that they want to have sex with, or if men who want to have sex with them buy them drinks. Men replied on 5-point scales (e.g., "Never" (0) – "Always" (4)). Hazardous drinking was evaluated using the Alcohol Use Disorders Identification Test – Consumption (AUDIT-C), (Bohn et al., 1995; Saunders et al., 1993), a scale developed and validated by the World Health Organization for international use, including in South Africa (Bohn et al., 1995; Myer et al., 2008; Saunders et al., 1993), where it has been used in multiple studies (Jewkes et al., 2006; Peltzer et al., 2011; Peltzer et al., 2006). The AUDIT-C uses 3 items: how often the respondent drinks, how many drinks the respondent consumes in a typical day of drinking, and how frequently the respondent drinks six or more drinks at a time. Of a maximum score of 12 on the AUDIT-C, a score of four or more indicates hazardous drinking for men (Bush et al., 1998). Drug use practices were measured by asking men if they had ever used marijuana, poppers, cocaine, opiates, hallucinogens, amphetamines, and other club drugs. If they replied yes to any of these, they were asked if they had used them in the past year.

The survey also measured demographic characteristics (age, education, income, residence), psychosocial factors and behavioral attributes. Men's reasons for drinking were assessed using eleven items (Golding et al., 1992), representing three domains: drinking for a positive affect ( $\alpha = 0.87$ ), drinking to cope with negative affect ( $\alpha = 0.91$ ) and drinking to enhance social interactions ( $\alpha = 0.80$ ); (overall  $\alpha = 0.95$ ). A sample item on the drinking to enhance social

interactions scale is: “In the past year, how often did you drink because a drink helps you to have better sex?”. Men replied on a five-point scale (“Never” (1) – “Always” (5)). Men who did not drink were assigned to “Never” (1) on all of these items. The Sex-Related Alcohol Expectancy Scale (Dermen and Cooper, 1994a,b) was used to assess men’s expectancies about the effects of alcohol use on sexual behavior, representing three domains: enhancement of sexual experience ( $\alpha = 0.93$ ), increased sexual risk taking ( $\alpha = 0.91$ ), and disinhibition of sexual behavior ( $\alpha = 0.88$ ) (Kalichman and Simbayi, 2004; Morojele et al., 2006); (overall  $\alpha = 0.95$ ). A sample item is: “After a few drinks of alcohol I am more sexually responsive”. Men replied on a 4-point Likert scale (“Strongly disagree” (1) – “Strongly agree” (4)). Sexual attraction was assessed with the question “Do you currently feel more sexually attracted to men or to women?” and a 5-point response scale (1 = “Only to women”; 5 = “Only to men”). Men were coded as ‘Only attracted to men’ and ‘Also attracted to women’ because of the distribution of the participants’ responses. Sexual identification was assessed with the question “What word would you use to describe your sexuality? Would you call yourself gay, bisexual, or straight, or would you use another word?” There were a few men ( $n = 2$ ) who described themselves as transgender and they were grouped with other gay men because of how they overlapped in terms of other measures of sexual identity (e.g., masculinity/femininity, sexual attraction to women, etc.). There were also a few straight men ( $n = 15$ ) who reported sex with other men in the previous 12 months who were grouped with bisexual men because of how they overlapped in terms of other measures of sexual identity. Self-perceived masculinity/femininity was assessed with a 6-item scale with 3 items assessing level of masculinity and femininity each (Storms, 1979) ( $\alpha = 0.95$ ). Sexual identity confusion and internalized homophobia were assessed with subscales adapted from the Lesbian, Gay, and Bisexual Identity Scale (LGBIS) (Mohr and Fassinger, 2000, 2006). Sexual identity confusion was assessed with 4-items (e.g., “I am not totally sure what my sexual orientation is”) ( $\alpha = 0.89$ ). Internalized homophobia was assessed with 7-items (e.g., “I wish I were only sexually attracted to women”) ( $\alpha = 0.85$ ). Secrecy about one’s sexual orientation was assessed with an 8-item scale (Day and Schoenrade, 1997) ( $\alpha = 0.96$ ). Gender dysphoria was assessed over the past year using a 16-item scaled adapted from the Gender Identity/Gender Dysphoria Questionnaire for Adolescents and Adults (Deogracias et al., 2007; Singh et al., 2010) ( $\alpha = 0.93$ ). Sample items include: “How often have you thought of yourself as a woman in the past 12 months?” and “How often have you felt unhappy about having a male body in the past 12 months?” and used a 5-point response scale (1 = “Never”; 5 = “Always”). Sexual orientation-based discrimination was assessed using a 10-item scale asking how often in the past year men had experienced such things as verbal insults, threats of physical violence, sexually harassment or rape because of having sex with men; items used a 4-point response scale (0 = “Never”; 4 = “Often”) ( $\alpha = 0.87$ ). Men were also asked if they had ever experienced sexual abuse as a child, and if they ever received money or other incentives in return for sex (transactional sex). The survey also addressed two mental health conditions: anxiety and depression. Anxiety was considered positive if the participant responded ‘yes’ to the following two yes/no items: “Have you ever in your life had an anxiety attack – suddenly feeling fear or panic?” and “Have you had an anxiety attack in the last 4 weeks?” (Kroenke et al., 2010). Depression was assessed using the 2 items: “Over the last 2 weeks, how often have you been troubled by any of the following problems: little interest or pleasure in doing things?” and “Over the last 2 weeks, how often have you been troubled by any of the following problems: feeling down, depressed or hopeless?” Each item featured a 5-point response scale (“Not at all” (0) – “Nearly every day” (3)) ( $\alpha = 0.84$ ) (Kroenke et al., 2003; Kroenke et al., 2010).

The data on social network characteristics were acquired by having used RDS (Wejnert, 2010). This data includes connectedness to a social network of MSM, which is estimated using outdegree centrality: the number of other men that a participant successfully recruited for

inclusion in the study (Valente et al., 2004). Reports of alcohol use among members of one’s social network who also participated in the study were used to estimate social network drinking. For this study, social network drinking behavior was calculated as the proportion of a participant’s ties that screened positive as hazardous drinkers using the AUDIT-C. That value was then weighted towards the mean by the inverse proportion of the number of ties that we had data on over the maximum number of ties.

### 2.3. Statistical analyses

The specific objectives of our analyses were to: 1) describe alcohol use and abuse among black South African MSM; 2) describe associations between individual characteristics, social network characteristics and hazardous drinking; 3) assess which characteristics are independently associated with hazardous drinking.

Tests to determine which variables were associated with hazardous drinking included *t*-tests for continuous and scaled variables and Chi-squared tests for dichotomous variables. All predictors explored in bivariate analyses were included in the final multivariable model. Multivariable analyses were run using logistic regression for the outcome of hazardous drinking (yes versus no). All statistical tests were 2-sided and  $p < .05$  was considered statistically significant. Statistical analyses were performed with SPSS (version 17.0; SPSS, Chicago, IL) and R (version 3.3.2; R Core Team, Vienna, Austria) software packages.

Since RDS was the recruitment method used for this sample, all analyses were adjusted using an RDS II estimator (Salganik and Heckathorn, 2004; Volz and Heckathorn, 2008). This approach gives greater weight to those men with a small personal network size, since those men would be less likely to be recruited into the study. Equilibrium for certain characteristics was assessed and considered to be achieved when the proportions of the dichotomized variable changed by less than .02 between waves.

## 3. Results

### 3.1. Sample characteristics

In total 480 eligible participants were recruited in 18 waves between August 2011 and January 2013. All results presented are RDS-weighted. The mean number of peers recruited by each participant was 0.7. The coupon return rate was 32% (460/1417). Among the 20 seeds, 40% were less than 24 years old, 75% had some post-secondary education, 65% had a regular income, and 90% lived in a township (versus metropolitan Tshwane). Among the entire sample, most men (57%) were less than 24 years old, 52% had some post-secondary education, 35% had a regular income, and 57% lived in a township (see Table 1). The study reached equilibrium on the following characteristics in the respective waves: age (wave 2), education (wave 3), income (wave 3), township status (wave 12), sexual identity (wave 3), sexual attraction (wave 3) and HIV status (wave 2). The sample has been described previously (Knox et al., 2017; Sandfort et al., 2015). The prevalence of HIV among the sample was 30% and hazardous drinking was identified as an independent risk factor for HIV infection (aOR = 1.8, 95%CI = 1.1–3.1,  $p < .05$ ) (Sandfort et al., 2015).

### 3.2. Alcohol and drug use

Most men (86%) had consumed alcohol in their lifetime, including 77% of men who had consumed alcohol in the past year. Among men who consumed alcohol in the past year, 49% consumed mostly beer, 36% consumed mostly cider (fermented alcoholic beverage made from apples), 9% ( $n = 33$ ) consumed mostly wine, and a small proportion (4%) consumed mostly spirits. The majority of men mostly consumed alcohol in bars and shebeens (informal drinking establishments located in townships) (53%), although many consumed alcohol equally as often

**Table 1**  
 Characteristics of MSM and hazardous drinking among n = 480 black MSM in Tshwane, South Africa (RDS-weighted).

	Total		Hazardous drinking		No hazardous drinking		X <sup>2</sup>	P
	N	(%)	N	(%)	N	(%)		
<b>Demographic characteristics</b>								
<b>Age</b>								
23 or younger	272	57%	171	63%	101	37%	0.3	0.61
24 or older	208	43%	126	61%	82	39%		
<b>Education</b>								
Secondary or lower	229	48%	153	67%	76	33%	4.5	0.03
Post secondary	251	52%	144	57%	107	43%		
<b>Regular income</b>								
No	311	65%	192	62%	119	38%	0.0	0.97
Yes	168	35%	104	62%	64	38%		
<b>Living in a township</b>								
No	204	43%	109	53%	95	47%	10.2	0.00
Yes	274	57%	186	68%	88	32%		
<b>Psychosocial factors (dichotomous)</b>								
<b>Sexual identification</b>								
Gay or transgender	332	70%	192	58%	140	42%	6.7	0.01
Bisexual or straight	145	30%	102	70%	43	30%		
<b>Sexual attraction</b>								
Only attracted to men	320	67%	177	55%	143	45%	17.5	< .001
Also attracted to women	160	33%	120	75%	40	25%		
<b>Ever received money or incentives for sex</b>								
No	369	77%	209	57%	160	43%	18.5	< .001
Yes	111	23%	88	79%	23	21%		
<b>Sexually abused as a child</b>								
No	429	89%	254	59%	175	41%	12.2	< .001
Yes	51	11%	43	84%	8	16%		
<b>Anxiety</b>								
No	431	89%	253	59%	178	41%	17.4	< .001
Yes	51	11%	43	84%	8	16%		
<b>Psychosocial factors (continuous)<sup>a</sup></b>								
	mean	SD	mean	SD	mean	SD	t	P
Femininity <sup>b</sup>	2.9	1.1	2.9	1.1	3.0	1.0	0.7	0.47
Sexual identify confusion <sup>c</sup>	2.0	0.6	2.1	0.6	2.0	0.5	-1.6	0.12
Secretiveness about sexuality <sup>c</sup>	2.2	0.9	2.2	0.9	2.2	0.9	0.1	0.92
Internalized homophobia <sup>b</sup>	2.1	0.5	2.2	0.5	2.1	0.5	-1.2	0.24
Gender dysphoria <sup>d</sup>	0.7	1.0	0.8	1.1	0.5	0.9	-2.9	0.00
Sexual orientation-based discrimination <sup>c</sup>	1.5	0.6	1.5	0.6	1.5	0.5	-1.6	0.10
Depression <sup>c</sup>	1.5	0.7	1.6	0.8	1.4	0.6	-2.6	0.01
<b>Social network characteristics<sup>1</sup></b>								
Social network connectedness <sup>e</sup>	0.7	1.1	0.7	1.1	0.8	1.1	0.3	0.77
Social network drinking behavior <sup>f</sup>	0.6	0.1	0.7	0.1	0.6	0.2	-3.9	< .001

<sup>a</sup> Higher scores indicate higher levels of the construct.  
<sup>b</sup> Range 1–5.  
<sup>c</sup> Range 1–4.  
<sup>d</sup> Range 0–4.  
<sup>e</sup> Range 0–5.  
<sup>f</sup> Range 0–1.

at home as they did while going out (27%) or mostly at home (20%). Most men (53%) said they commonly consumed alcohol before going out to a bar or shebeen. More than half of men (51%) reported either buying alcohol for men that they wanted to have sex with or being bought alcohol by men who wanted to have sex with them.

In response to the items that comprise the AUDIT-C: 20% of men drank twice a week or more, 29% drank 2–4 times per month, and 28% drank once a month or less. A fifth of the men (21%) reported that they have 10 or more drinks on a typical day that they are drinking, 11% have 7–9 drinks, 23% have 5 or 6 drinks, 17% have 3 or 4 drinks, and only 5% have 1 or 2 drinks. A quarter of men (24%) reported that they have 6 or more drinks on a single occasion weekly, 22% have 6 or more drinks on a single occasion monthly, and 22% have 6 or more drinks on a single occasion less than monthly but not never. The mean AUDIT-C score was 4.7 and the median AUDIT-C score was 4.4. More than half of the men (62%, 95%CI = 56%–68%) screened positive as hazardous drinkers. Fig. 1 shows the distribution of these men among the recruitment threads. The study reached equilibrium on hazardous drinking after 2 waves.

In the past year, 16% of men had used drugs. Men most commonly used marijuana (15%). A few men had used poppers (< 1%), cocaine (1%), crack (< 1%), crystal methamphetamine (< 1%), methaqualone (< 1%), hallucinogens (< 1%), heroin (1%), or amphetamines (3%). Because hazardous drinking was found to be the vastly predominant form of substance use among this population, it served as the focus of all further analyses.

### 3.3. Reasons for drinking and sex-related alcohol expectancies

Table 2 shows the results of how reasons for drinking and sex-related alcohol expectancies correlated with hazardous drinking. Men who screened positive as hazardous drinkers were more likely to endorse drinking for a positive affect ( $p < .001$ ), drinking to cope with negative affect ( $p < .001$ ) and drinking to enhance social interactions ( $p < .001$ ). Men who screened positive as hazardous drinkers were more likely to expect alcohol to enhance sexual experience ( $p < .001$ ), increase sexual risk taking ( $p < .001$ ) and disinhibit sexual behavior ( $p < .001$ ).



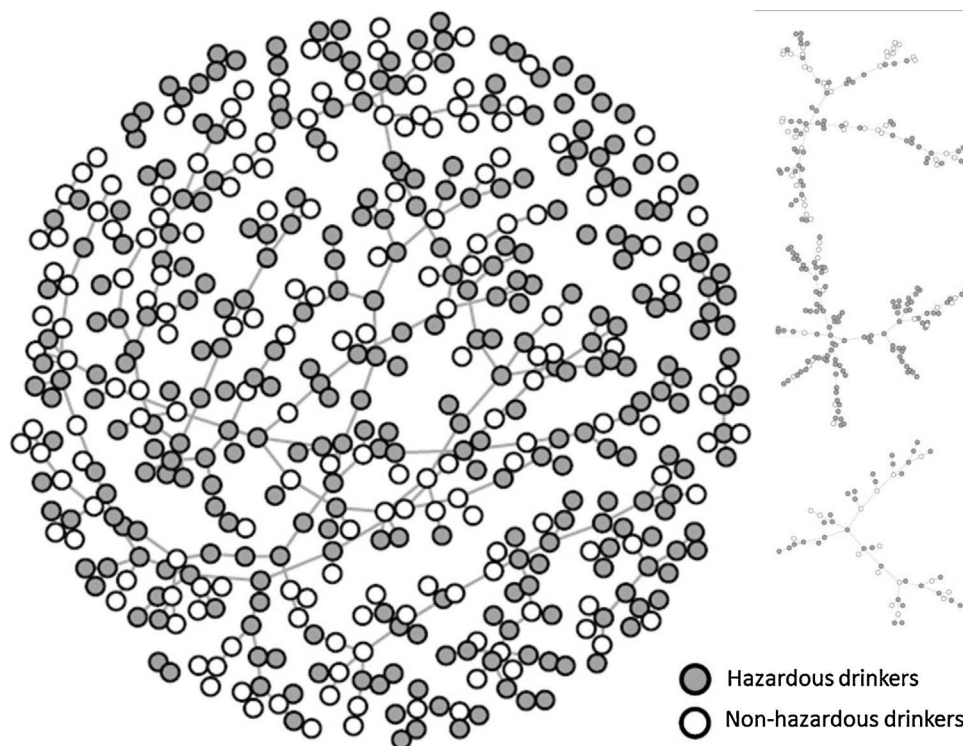


Fig. 1. Distribution of hazardous drinkers among networks of n = 480 black MSM in Pretoria, South Africa, with 3 distinct network chains extracted.

### 3.4. Correlates of hazardous drinking

In bivariate analyses, men who screened positive as hazardous drinkers were more likely to have a secondary education or lower ( $P = .03$ ), identify as straight or bisexual (versus gay;  $p = .01$ ), be attracted to both men and women ( $P < .001$ ), have ever received money or other incentives in return for sex ( $p < .001$ ), have been sexually abused as a child ( $p < .001$ ), have higher levels of anxiety ( $p < .001$ ), experience more gender dysphoria ( $p < .01$ ), and have higher levels of depression ( $p = < .01$ ) (see Table 1). Men who screened positive as hazardous drinkers were not more connected, on average, to this social network of MSM ( $p = .77$ ). Men who screened positive as hazardous drinkers had a higher proportion of friends, on average, who were also hazardous drinkers ( $p = < .01$ ).

Table 3 shows the results of both unweighted and RDS-weighted multivariable analyses looking at independent correlates of hazardous drinking. The measures of association from the unweighted and RDS-weighted analyses are similar in terms of their direction and strength of association. There are multiple discrepancies in terms of achieving statistical significance. Among RDS-weighted analyses, living in a township (versus the city of Pretoria) (aOR = 1.9, 95%CI = 1.2–3.1,

$p < .01$ ), more gender dysphoria (aOR = 1.4, 95%CI = 1.0–1.8,  $p = .03$ ), having ever received money or other incentives in return for sex (aOR = 2.4, 95%CI = 1.3–4.3,  $p < .01$ ), having been sexually abused as a child (aOR = 2.6, 95%CI = 1.1–6.4,  $p = .03$ ), having anxiety (aOR = 5.4, 95%CI = 1.2–24.3,  $p = .03$ ), and social network drinking behavior (aOR = 5.4, 95%CI = 1.2–24.3,  $p = .03$ ) were positively associated with hazardous drinking. Being sexually attracted only to men (aOR = 0.3, 95%CI = 0.1–0.8,  $p = .01$ ) was negatively associated with hazardous drinking.

### 4. Discussion

Black South African MSM were found to have high levels of alcohol use; nearly two thirds (62%, 95%CI = 56%–68%) of them screened positive as hazardous drinkers. Various factors were found to increase men’s likelihood of being hazardous drinkers. Men who live in a township (versus the city of Pretoria), men with higher levels of gender dysphoria, men who had ever received money or other incentives in return for sex, men who had been sexually abused as a child, and men with anxiety were all more likely to be hazardous drinkers. Men who reported being sexually attracted only to men were less likely to be

Table 2  
Reasons for drinking, sex-related alcohol expectancies and hazardous drinking among n = 480 black MSM in Tshwane, South Africa.

	Total		Hazardous drinking		No hazardous drinking		t	P
	mean	SD	mean	SD	mean	SD		
Reasons for drinking								
Drinking for positive affect	2.5	1.2	3.1	0.9	1.5	0.8	-19.5	< .001
Drinking for negative affect	2.1	1.1	2.5	1.1	1.4	0.7	-12.5	< .001
Drinking to enhance social interactions	2.4	1.2	2.9	1.1	1.5	0.9	-14.9	< .001
All reasons for drinking	2.3	1.1	2.8	0.9	1.5	0.8	-17.0	< .001
Sex-related alcohol expectancies								
Enhancement of sexual experience	2.6	0.6	2.7	0.5	2.4	0.7	-6.0	< .001
Increased sexual risk taking	2.3	0.6	2.4	0.5	2.2	0.7	-3.4	< .001
Disinhibition of sexual behavior	2.3	0.6	2.4	0.5	2.1	0.7	-5.9	< .001
All sex-related alcohol expectancies	2.4	0.6	2.3	0.6	2.5	0.4	-5.6	< .001

**Table 3**  
Risk factors for hazardous drinking among n = 480 black MSM in Tshwane, South Africa.

	Unweighted			RDS-weighted		
	aOR	95% CI	P	aOR	95% CI	P
<b>Demographic characteristics</b>						
Older than 24 (vs. 24 or younger)	0.7	0.5–1.1	0.16	0.7	0.4–1.1	0.12
Post secondary education (vs. high school or less)	1.0	0.7–1.6	0.85	0.9	0.5–1.3	0.48
Has a regular income (vs. not)	1.4	0.9–2.1	0.21	1.2	0.7–1.9	0.53
Living in a township (vs. not)	1.5	1.0–2.4	0.07	1.9	1.2–3.1	< 0.01
<b>Psychosocial factors<sup>1</sup></b>						
Identify as gay or transgender (vs. bisexual or straight)	1.2	0.5–2.9	0.62	1.4	0.5–3.6	0.49
Only sexually attracted to men (vs. also attracted to women)	0.5	0.2–1.0	0.05	0.3	0.1–0.8	0.01
Femininity	0.8	0.6–1.0	0.06	0.8	0.6–1.1	0.14
Sexual identify confusion	1.1	0.7–1.7	0.63	1.1	0.7–1.7	0.80
Secretiveness about sexuality	1.1	0.8–1.5	0.75	0.9	0.7–1.3	0.64
Internalized homophobia	0.7	0.4–1.2	0.23	1.1	0.6–1.9	0.85
Gender dysphoria	1.2	0.9–1.6	0.13	1.4	1.0–1.8	0.03
Sexual orientation-based discrimination	0.9	0.6–1.4	0.61	0.8	0.5–1.2	0.31
Ever received money or incentives for sex (vs. not)	2.7	1.5–4.9	< 0.01	2.4	1.3–4.3	< 0.01
Sexually abused as a child (vs. not)	2.0	1.1–7.7	0.08	2.7	1.1–6.5	0.03
Anxiety	2.9	1.1–7.7	0.04	6.1	2.1–17.3	0.00
Depression	1.1	0.7–1.5	0.76	1.0	0.7–1.5	0.91
<b>Social network characteristics<sup>1</sup></b>						
Social network connectedness	1.1	0.9–1.3	0.28	1.1	0.9–1.3	0.41
Social network drinking behavior	3.9	1.0–16.0	0.06	5.4	1.2–24.3	0.03

1. Higher scores indicate higher levels of the construct.

hazardous drinkers. Men whose social networks included a higher proportion of hazardous drinkers were more likely to be hazardous drinkers themselves.

The high levels of alcohol use found in the current study are comparable to what has been described in other studies conducted among black South African MSM, which focused on alcohol use as a risk factor for risk behavior (Lane et al., 2008) or HIV infection (Lane et al., 2011; Rispel et al., 2011). In one study, nearly two thirds of men reported drinking regularly, with nearly half reporting that they get drunk regularly (Lane et al., 2008). In another study, over half of men reported having 10 or more drinks in a typical day of drinking and more than three quarters of men were classified as having a drinking problem (Lane et al., 2011). In another study, nearly three quarters of men reported having sex while under the influence of alcohol (Rispel et al., 2011). Substance use is a major health concern among this population, especially given its association with high risk sexual behavior (Bryant, 2006; Kalichman et al., 2007; Rehm et al., 2012; Woolf-King and Maisto, 2011) in this setting of high HIV prevalence (Lane et al., 2011; Rispel et al., 2011; Sandfort et al., 2015). Despite the heavy burden of alcohol use, among these men and other African MSM populations, the authors were unable to identify any implemented interventions that have targeted alcohol use among these men or any other African MSM population (Sandfort et al., in press). Clearly, this is a public health problem that merits further attention.

Men who were hazardous drinkers were more likely to endorse drinking for a positive affect, drinking for negative effect and drinking to enhance social interaction. Men who were hazardous drinkers were also more likely to expect alcohol to enhance sexual experience, increase sexual risk taking and disinhibit sexual behavior. Much of the research on reasons for drinking and sex-related alcohol expectancies indicate that drinking is more likely to have an intended effect on people that endorse these beliefs (Bryan et al., 2007; Dermen et al., 1998; Fromme et al., 1999; Gordon et al., 1997; McKirnan et al., 2001), thus suggesting that hazardous drinking additionally leads to increased sexual risk behavior.

The current project is the first to identify determinants of hazardous drinking among a sample of African MSM. Living in a township (versus metropolitan Tshwane), a construct that captures the vulnerability of living in a low resource setting, was found to increase men's likelihood

of being hazardous drinkers. This risk factor has been observed as an important indicator of social vulnerability and predictor of health risk in studies conducted among black South African MSM (Knox et al., 2013, 2011, 2010; Sandfort et al., 2013).

Other indicators of social vulnerability were also found to increase men's likelihood of being hazardous drinkers. The relationships we observed are in accordance with what has been found among non-African MSM populations. Indicators of sexual minority stress, such as gender dysphoria, have been found to be associated with substance abuse (McKirnan and Peterson, 1989b; Rosario et al., 2006; Stall et al., 2001). In this study, gender dysphoria predicted hazardous drinking while controlling for other same-sex characteristics, suggesting that there is something uniquely detrimental about these feelings that they contribute to hazardous drinking. Similar to our findings, other studies have found childhood sexual abuse (Diaz et al., 1999; Paul et al., 2001) and mental health indicators, including anxiety (Rosario et al., 2006; Stall et al., 2001), to predict substance abuse among non-African MSM populations. These findings are of heightened concern because of how these co-occurring health problems work synergistically to increase risk of HIV infection (Jie et al., 2012; Stall et al., 2003).

Men who reported being sexually attracted to both men and women were more likely to be hazardous drinkers than men who reported sexual attraction to only men. This result was observed while controlling for other potentially more proximal psychosocial characteristics that might help explain the association, such as sexual identify confusion or internalized homophobia. Another potential explanation for this might be that local community social support networks are stronger for gay MSM than they are for bisexual MSM. Further research into the dynamics of how sexual identity contributes to risk among these men, both in terms of hazardous drinking and sexual vulnerability, is needed.

The current project is also the first to consider social network characteristics in the evaluation of substance use among a sample of African MSM. We found that the size of men's social network did not impact men's likelihood of being a hazardous drinker, although the drinking behavior of their social network members did. This finding speaks to the importance of the characteristics of social network ties because they provide a context for behavior and norms (Friedman et al., 2007; Latkin et al., 2009; Luke and Harris, 2007; Valente and Fosados, 2006), more than concern for the presence of social network ties in

themselves (i.e., being connected versus isolated) (Alexander et al., 2001; HELLERINGER and KOHLER, 2007; Smith et al., 2004). This is an area that merits further exploration, particularly given the heightened importance of social networks in this setting (Latkin et al., 2013) and their potential as conduits for an intervention (Latkin, 1998).

There are certain limitations to the current study. The cross-sectional research design limits the ability to infer causality. For example, we assume that the drinking behaviors of one's social network members influences one's own drinking behavior. However, these findings may also reflect that men who drink more tend to befriend other men who drink more. There were also certain findings that were not in agreement with our expectations. For example, it is not clear why being sexually attracted only to men decreased men's likelihood of being a hazardous drinker when in previous research this was found to predict alcohol dependence (Stall et al., 2001). Furthermore, some potential risk factors were not found to be associated with hazardous drinking. This likely speaks to the exploratory nature of this study, given the lack of previous research among African MSM populations, as well as the complexity of substance use and psychosocial health among men in this setting (Cook et al., 2013; Sandfort et al., 2016, 2015). These issues merit further exploration. Unfortunately, the study did not collect information on being on treatment for HIV. Given how few men knew their current HIV status, the limited availability of antiretroviral therapy (ART) during the study period and the criteria for starting treatment at the time, we suspect that few men were on ART. The current study was conducted among black South African MSM and may have limited generalizability outside of that setting. The constructs used were almost exclusively developed in Western settings, and while many of them have previously been demonstrated to be reliable and valid, including many in South Africa, there may be additional culture-specific factors that have not been accounted for. Lastly, the data collected are self-reported and could have been subject to social desirability or recall bias.

In summary, the current study expands the literature by providing further evidence of the severity of excessive alcohol use among black South African MSM. Various determinants of hazardous drinking were identified, including many indicators of social vulnerability. The findings are of concern because these health problems often work synergistically to increase risk of HIV infection. The drinking habits of men's social network ties also was highly correlated with men's own drinking habits. These findings should be taken into consideration by efforts aimed at reducing hazardous drinking among this critical population. Specifically, intervention strategies should consider targeting MSM who are the most vulnerable, those who live in townships, who have had to engage in sex for money or favors, who have a history of childhood sexual abuse or who suffer from other mental health problems. Possible interventions might include those that not only target individuals but their social networks (Copello et al., 2002). Efforts aimed at reducing hazardous drinking are greatly needed.

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#### Contributors

All authors have seen, approved, and contributed significantly to this manuscript. For a breakdown of contributions: Conceived and designed the experiments: TS, VR, TL. Performed the experiments: TS, VR. Analyzed the data: JK, TS. Wrote the paper: JK, VR, TL, GL, DH, TS.

#### Conflict of interest

None of the authors have conflict of interest to disclose.

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#### References

- Adam, P.C.G., de Wit, J.B.E., Toskin, I., Mathers, B.M., Nashkoev, M., Zablotska, I., Lyster, R., Rugg, D., 2009. Estimating levels of HIV testing, HIV prevention coverage, HIV knowledge, and condom use among men who have sex with men (MSM) in low-income and middle-income countries. *J. Acquir. Immune Defic. Syndr.* 52, S143–S151.
- Alexander, C., Piazza, M., Mekos, D., Valente, T., 2001. Peers, schools, and adolescent cigarette smoking. *J. Adolesc. Health* 29, 22–30.
- Bohn, M.J., Babor, T.F., Kranzler, H.R., 1995. The Alcohol Use Disorders Identification Test (AUDIT): validation of a screening instrument for use in medical settings. *J. Stud. Alcohol* 56, 423–432.
- Bryan, A.D., Ray, L.A., Cooper, M.L., 2007. Alcohol use and protective sexual behaviors among high-risk adolescents. *J. Stud. Alcohol Drugs* 68, 327–335.
- Bryant, K.J., 2006. Expanding research on the role of alcohol consumption and related risks in the prevention and treatment of HIV/AIDS. *Subst. Use Misuse* 41, 1465–1507.
- Bush, K., Kivlahan, D.R., McDonnell, M.B., Fihn, S.D., Bradley, K.A., 1998. The AUDIT alcohol consumption questions (AUDIT-C): an effective brief screening test for problem drinking. *Arch. Intern. Med.* 158, 1789–1795.
- Cook, S.H., Sandfort, T.G., Nel, J.A., Rich, E.P., 2013. Exploring the relationship between gender nonconformity and mental health among black South African gay and bisexual men. *Arch. Sex. Behav.* 42, 327–330.
- Copello, A., Orfor, J., Hodgson, R., Tober, G., Barrett, C., UKATT Research Team, 2002. Social behaviour and network therapy basic principles and early experiences. *Addict. Behav.* 27, 345–366. <https://www.ncbi.nlm.nih.gov/pubmed/?term=United+Kingdom+Alcohol+Treatment+Trial%2C+Social+behaviour+and+network+therapy+basic+principles+and+early+experiences>.
- Day, N.E., Schoenrade, P., 1997. Staying in the closet versus coming out: relationships between communication about sexual orientation and work attitudes. *Pers. Psychol.* 50, 147–163.
- Deogracias, J.J., Johnson, L.L., Meyer-Bahlburg, H.F.L., Kessler, S.J., Schober, J.M., Zucker, K.J., 2007. The gender identity/gender dysphoria questionnaire for adolescents and adults. *J. Sex Res.* 44, 370–379.
- Dermen, K.H., Cooper, M.L., 1994a. Sex-related alcohol expectancies among adolescents: I. Scale development. *Psychol. Addict. Behav.* 8, 152–160.
- Dermen, K.H., Cooper, M.L., 1994b. Sex-related alcohol expectancies among adolescents: II. Prediction of drinking in social and sexual situations. *Psychol. Addict. Behav.* 8, 161–168.
- Dermen, K.H., Cooper, M.L., Agocha, V.B., 1998. Sex-related alcohol expectancies as moderators of the relationship between alcohol use and risky sex in adolescents. *J. Stud. Alcohol* 59, 71–77.
- Diaz, R.M., Morales, E.S., Bein, E., Dilan, E., Rodriguez, R.A., 1999. Predictors of sexual risk in latino gay/bisexual men: the role of demographic, developmental, social cognitive, and behavioral variables. *Hispanic J. Behav. Sci.* 21, 480–501.
- Doherty, I.A., Padian, N.S., Marlow, C., Aral, S.O., 2005. Determinants and consequences of sexual networks as they affect the spread of sexually transmitted infections. *J. Infect. Dis.* 191, S42–S54.
- Friedman, S.R., Aral, S., 2001. Social networks, risk-potential networks, health, and disease. *J. Urban Health* 78, 411–418.
- Friedman, S.R., Bolyard, M., Mateu-Gelabert, P., Goltzman, P., Pawlowicz, M.P., Singh, D.Z., Touze, G., Rossi, D., Maslow, C., Sandoval, M., Flom, P.L., 2007. Some data-driven reflections on priorities in AIDS network research. *AIDS Behav.* 11, 641–651.
- Fromme, K., D'Amico, E.J., Katz, E.C., 1999. Intoxicated sexual risk taking: an expectancy or cognitive impairment explanation? *J. Stud. Alcohol* 60, 54–63.
- Gaughan, M., 2003. Predisposition and pressure: mutual influence and adolescent drunkenness. *Connections* 25, 17–31.
- Golding, J.M., Burnam, M.A., Benjamin, B., Wells, K.B., 1992. Reasons for drinking, alcohol use, and alcoholism among Mexican Americans and non-Hispanic Whites. *Psychol. Addict. Behav.* 6, 155–167.
- Gordon, C.M., Carey, M.P., Carey, K.B., 1997. Effects of a drinking event on behavioral skills and condom attitudes in men: implications for HIV risk from a controlled experiment. *Health Psychol.* 16, 490–495.
- Heath, A.C., Martin, N.G., 1991. The inheritance of alcohol sensitivity and of patterns of alcohol use. *Alcohol Alcohol. Suppl.* 1, 141–145.
- Heath, D.B., 1991. Uses and misuses of the concept of ethnicity in alcohol studies—an essay in deconstruction. *Int. J. Addict.* 25, 607–628.
- Heckathorn, D.D., Semaan, S., Broadhead, R.S., Hughes, J.J., 2002. Extensions of respondent-driven sampling: a new approach to the study of injection drug users aged 18–25. *Aids Behav.* 6, 55–67.
- Heckathorn, D.D., 1997. Respondent-driven sampling: a new approach to the study of hidden populations. *Soc. Probl.* 44, 174–199.
- Helleringer, S., Kohler, H.P., 2007. Sexual network structure and the spread of HIV in Africa: evidence from Likoma Island, Malawi. *AIDS* 21, 2323–2332.
- Jewkes, R., Nduna, M., Levin, J., Jama, N., Dunkle, K., Khuzwayo, N., Koss, M., Puren, A., Wood, K., Duvvury, N., 2006. A cluster randomized-controlled trial to determine the effectiveness of Stepping Stones in preventing HIV infections and promoting safer

- sexual behaviour amongst youth in the rural Eastern Cape, South Africa: trial design, methods and baseline findings. *Trop. Med. Int. Health* 11, 3–16.
- Jie, W., Ciyong, L., Xueqing, D., Hui, W., Lingyao, H., 2012. A syndemic of psychosocial problems places the MSM (men who have sex with men) population at greater risk of HIV infection. *PLoS One* 7.
- Kalichman, S.C., Simbayi, L.C., 2004. Sexual assault history and risks for sexually transmitted infections among women in an African township in Cape Town, South Africa. *AIDS Care* 16, 681–689.
- Kalichman, S.C., Simbayi, L.C., Kaufman, M., Cain, D., Jooste, S., 2007. Alcohol use and sexual risks for HIV/AIDS in sub-Saharan Africa: systematic review of empirical findings. *Prev. Sci.* 8, 141–151.
- Knox, J., Yi, H., Reddy, V., Maimane, S., Sandfort, T., 2010. The fallacy of intimacy: dexual risk behaviour and beliefs about trust and condom use among men who have sex with men in South Africa. *Psychol. Health Med.* 15, 660–671.
- Knox, J., Sandfort, T., Yi, H., Reddy, V., Maimane, S., 2011. Social vulnerability and HIV testing among South African men who have sex with men. *Int. J. STD AIDS* 709–713.
- Knox, J., Reddy, V., Kaigobadi, F., Nel, D., Sandfort, T., 2013. Communicating HIV status in sexual interactions assessing social cognitive constructs, situational factors, and individual characteristics among South African MSM. *AIDS Behav.* 17, 350–359.
- Knox, J., Reddy, V., Lane, T., Hasin, D., Sandfort, T., 2017. Substance use and sexual risk behavior among black South African men who have sex with men: the moderating effects of reasons for drinking and safer sex intentions. *AIDS Behav.* 21, 2023–2032.
- Kroenke, K., Spitzer, R.L., Williams, J.B.W., 2003. The Patient Health Questionnaire-2 – validity of a two-item depression screener. *Med. Care* 41, 1284–1292.
- Kroenke, K., Spitzer, R.L., Williams, J.B.W., Lowe, B., 2010. The Patient Health Questionnaire Somatic, Anxiety, and Depressive Symptom Scales: a systematic review. *Gen. Hosp. Psychiatry* 32, 345–359.
- Lane, T., Shade, S.B., McIntyre, J., Morin, S.F., 2008. Alcohol and sexual risk behavior among men who have sex with men in South African township communities. *AIDS Behav.* 12, 878–885.
- Lane, T., Raymond, H.F., Dladla, S., Raseth, J., Struthers, H., McFarland, W., McIntyre, J., 2011. High HIV prevalence among men who have sex with men in Soweto, South Africa: results from the Soweto Men's Study. *AIDS Behav.* 15, 626–634.
- Latkin, C., Donnell, D., Celentano, D.D., Aramrattana, A., Liu, T.Y., Vongchak, T., Wiboonnatakul, K., Davis-Vogel, A., Metzger, D., 2009. Relationships between social norms, social network characteristics, and HIV risk behaviors in Thailand and the United States. *Health Psychol.* 28, 323–329.
- Latkin, C.A., Davey-Rothwell, M.A., Knowlton, A.R., Alexander, K.A., Williams, C.T., Boodram, B., 2013. Social network approaches to recruitment, HIV prevention, medical care, and medication adherence. *J. Acquir. Immune Defic. Syndr.* 63 (Suppl. 1), S54–58.
- Latkin, C.A., 1998. Outreach in natural settings: the use of peer leaders for HIV prevention among injecting drug users' networks. *Public Health Rep.* 113 (Suppl. 1), 151–159.
- Luke, D.A., Harris, J.K., 2007. Network analysis in public health: history, methods, and applications. *Annu. Rev. Public Health* 28, 69–93.
- Magnani, R., Sabin, K., Sidel, T., Heckathorn, D., 2005. Review of sampling hard-to-reach and hidden populations for HIV surveillance. *AIDS* 19 (Suppl. 2), S67–72.
- McKirnan, D.J., Peterson, P.L., 1989a. Alcohol and drug use among homosexual men and women: epidemiology and population characteristics. *Addict. Behav.* 14, 545–553.
- McKirnan, D.J., Peterson, P.L., 1989b. Psychosocial and cultural factors in alcohol and drug abuse: an analysis of a homosexual community. *Addict. Behav.* 14, 555–563.
- McKirnan, D.J., Vanable, P.A., Ostrow, D.G., Hope, B., 2001. Expectancies of sexual escape and sexual risk among drug and alcohol-involved gay and bisexual men. *J. Subst. Abuse* 13, 137–154.
- Mohr, J.J., Fassinger, R.E., 2000. Measuring dimensions of lesbian and gay male experience. *Meas. Eval. Couns. Dev.* 33, 66–90.
- Mohr, J.J., Fassinger, R.E., 2006. Sexual orientation identity and romantic relationship quality in same-sex couples. *Pers. Soc. Psychol. Bull.* 32, 1085–1099.
- Morojele, N.K., Kachieng'a, M.A., Mokoko, E., Nkoko, M.A., Parry, C.D., Nkowane, A.M., Moshia, K.M., Saxena, S., 2006. Alcohol use and sexual behaviour among risky drinkers and bar and shebeen patrons in Gauteng province, South Africa. *Soc. Sci. Med.* 62, 217–227.
- Muraguri, N., Temmerman, M., Geibel, S., 2012. A decade of research involving men who have sex with men in sub-Saharan Africa: current knowledge and future directions. *SAHARA J.* 9, 137–147.
- Myer, L., Smit, J., Roux, L.L., Parker, S., Stein, D.J., Seedat, S., 2008. Common mental disorders among HIV-infected individuals in South Africa: prevalence, predictors, and validation of brief psychiatric rating scales. *AIDS Patient Care STDS* 22, 147–158.
- Niang, C.I., Tapsoba, P., Weiss, E., Diagne, M., Niang, Y., Moreau, A.M., Gomis, D., Wade, A.S., Seck, K., Castle, C., 2003. 'It's raining stones': stigma, violence and HIV vulnerability among men who have sex with men in Dakar, Senegal. *Cult. Health Sex.* 5, 499–512.
- Paul, J.P., Catania, J., Pollack, L., Stall, R., 2001. Understanding childhood sexual abuse as a predictor of sexual risk-taking among men who have sex with men: the Urban Men's Health Study. *Child Abuse Negl.* 25, 557–584.
- Peltzer, K., Seoka, P., Babor, T., Obot, I., 2006. Training primary care nurses to conduct alcohol screening and brief interventions in South Africa. *Curatation* 29, 16–21.
- Peltzer, K., Davids, A., Njuho, P., 2011. Alcohol use and problem drinking in South Africa: findings from a national population-based survey. *Afr. J. Psychiatry* 14, 30–37.
- Rabie, F., Lesch, E., 2009. 'I am like a woman': constructions of sexuality among gay men in a low-income South African community. *Cult. Health Sex.* 11, 717–729.
- Rehm, J., Shield, K.D., Joharchi, N., Shuper, P.A., 2012. Alcohol consumption and the intention to engage in unprotected sex: systematic review and meta-analysis of experimental studies. *Addiction* 107, 51–59.
- Rispel, L.C., Metcalf, C.A., Cloete, A., Reddy, V., Lombard, C., 2011. HIV prevalence and risk practices among men who have sex with men in two South African cities. *J. Acquir. Immune Defic. Syndr.* 57, 69–76.
- Rosario, M., Schrimshaw, E.W., Hunter, J., 2006. A model of sexual risk behaviors among young gay and bisexual men: longitudinal associations of mental health, substance abuse, sexual abuse, and the coming-out process. *AIDS Educ. Prev.* 18, 444–460.
- Salganik, M.J., Heckathorn, D.D., 2004. Sampling and estimation in hidden populations using respondent driven sampling. *Sociol. Methodol.* 34, 193–240.
- Sandfort, T.G., de Graaf, R., Bijl, R.V., Schnabel, P., 2001. Same-sex sexual behavior and psychiatric disorders: findings from the Netherlands Mental Health Survey and Incidence Study (NEMESIS). *Arch. Gen. Psychiatry* 58, 85–91.
- Sandfort, T., Yi, H., Knox, J., Reddy, V., 2013. Sexual partnership types as determinant of HIV risk in South African MSM: an event-level cluster analysis. *AIDS Behav.* 17 (Suppl. 1), S23–32.
- Sandfort, T.G., de Graaf, R., Ten Have, M., Ransome, Y., Schnabel, P., 2014. Same-sex sexuality and psychiatric disorders in the second Netherlands Mental Health Survey and Incidence Study (NEMESIS-2). *LGBT Health* 1, 292–301.
- Sandfort, T.G., Lane, T., Dolezal, C., Reddy, V., 2015. Gender expression and risk of HIV infection among black South African men who have sex with men. *AIDS Behav.* 19, 2270–2279.
- Sandfort, T., Bos, H., Knox, J., Reddy, V., 2016. Gender nonconformity, discrimination, and mental health among black South African men who have sex with men: a further exploration of unexpected findings. *Arch. Sex. Behav.* 45, 661–670.
- Sandfort, T., Knox, J., Alcalá, C., El-Bassel, N., Kuo, I., Smith, L. Substance use and HIV risk among men who have sex with men in Africa: a systematic review. *J. Acquir. Immune Defic. Syndr.*, in press.
- Saunders, J.B., Aasland, O.G., Babor, T.F., de la Fuente, J.R., Grant, M., 1993. Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption-II. *Addiction* 88, 791–804.
- Singh, D., Deogracias, J.J., Johnson, L.L., Bradley, S.J., Kibblewhite, S.J., Owen-Anderson, A., Peterson-Badali, M., Meyer-Bahlburg, H.F.L., Zucker, K.J., 2010. The Gender Identity/Gender Dysphoria Questionnaire for adolescents and adults: further validity evidence. *J. Sex Res.* 47, 49–58.
- Smith, K.P., Christakis, N.A., 2008. Social networks and health. *Annu. Rev. Sociol.* 34, 405–429.
- Smith, A.M.A., Grierson, J., Wain, D., Pitts, M., Pattison, P., 2004. Associations between the sexual behaviour of men who have sex with men and the structure and composition of their social networks. *Sex. Transm. Infect.* 80, 455–458.
- Smith, A.D., Tapsoba, P., Peshu, N., Sanders, E.J., Jaffe, H.W., 2009. Men who have sex with men and HIV/AIDS in sub-Saharan Africa. *Lancet* 374, 416–422.
- Stall, R., Paul, J.P., Greenwood, G., Pollack, L.M., Bein, E., Crosby, G.M., Mills, T.C., Binson, D., Coates, T.J., Catania, J.A., 2001. Alcohol use, drug use and alcohol-related problems among men who have sex with men The Urban Men's Health Study. *Addiction (Abingdon, England)* 96, 1589–1601.
- Stall, R., Mills, T.C., Williamson, J., Hart, T., Greenwood, G., Paul, J., Pollack, L., Binson, D., Osmond, D., Catania, J.A., 2003. Association of co-occurring psychosocial health problems and increased vulnerability to HIV/AIDS among urban men who have sex with men. *Am. J. Public Health* 93, 939–942.
- Storms, M.D., 1979. Sex-role identity and its relationships to sex-role attributes and sex-role stereotypes. *J. Pers. Soc. Psychol.* 37, 1779–1789.
- Umberson, D., Montez, J.K., 2010. Social relationships and health: a flashpoint for health policy. *J. Health Soc. Behav.* 51, S54–S66.
- Valente, T.W., Fosados, R., 2006. Diffusion of innovations and network segmentation: the part played by people in promoting health. *Sex. Transm. Dis.* 33, S23–S31.
- Valente, T.W., Gallaher, P., Mouttapa, M., 2004. Using social networks to understand and prevent substance use: a transdisciplinary perspective. *Subst. Use Misuse* 39, 1685–1712.
- Valente, T.W., 2003. Social network influences on adolescent substance use: an introduction. *Connections* 25, 11–16.
- van Griensven, F., 2007. Men who have sex with men and their HIV epidemics in Africa. *AIDS* 21, 1361–1362.
- van Griensven, F., Sanders, E.J., 2008. Understanding HIV risks among men who have sex with men in Africa. *Sex. Transm. Dis.* 35, 355–356.
- Volz, E., Heckathorn, D.D., 2008. Probability based estimation theory for respondent driven sampling. *J. Off. Stat.* 24, 79–97.
- Wang, J., Hausermann, M., Ajdacic-Gross, V., Aggleton, P., Weiss, M.G., 2007. High prevalence of mental disorders and comorbidity in the Geneva Gay Men's Health Study. *Soc. Psychiatry Psychiatr. Epidemiol.* 42, 414–420.
- Wejnert, C., 2010. Social network analysis with respondent-driven sampling data: a study of racial integration on campus. *Soc. Netw.* 32, 112–124.
- Williams, E.C., Hahn, J.A., Saitz, R., Bryant, K., Lira, M.C., Samet, J.H., 2016. Alcohol use and Human Immunodeficiency Virus (HIV) infection: current knowledge, implications, and future directions. *Alcohol. Clin. Exp. Res.* 40, 2056–2072.
- Windle, M., 2000. Parental, sibling, and peer influences on adolescent substance use and alcohol problems. *Appl. Dev. Sci.* 4, 98–110.
- Woolf-King, S.E., Maisto, S.A., 2011. Alcohol use and high-risk sexual behavior in Sub-Saharan Africa: a narrative review. *Arch. Sex. Behav.* 40, 17–42.
- Youn, Y., Laumann, E.O., 2002. Social network effects on the transmission of sexually transmitted diseases. *Sex. Transm. Dis.* 29, 689–697.

## **Chapter 4 Safer sex intentions as a modifier of the relationship between substance use and sexual risk behavior during a specific sexual encounter**

### **Introduction**

Because of the global burden of HIV, especially in sub-Saharan Africa, a better understanding of the relationship between substance use and HIV risk behavior is a public health priority, particularly among populations with high rates of HIV transmission (1-4). Most research supports that substance use and sexual risk behavior are associated, including in sub-Saharan Africa (2-5). However, detailed reviews of the literature on this topic have noted inconsistencies, with many studies not identifying an association (6-9).

Possible explanations for these inconsistencies include the unmeasured moderating effects of other psychosocial factors (4, 8, 10-20). Such factors impact the magnitude or even the direction of the effect of an exposure on an outcome. In a recent study conducted among black South African men who have sex with men (MSM), we found that reasons for drinking and intentions to engage in safer sex modified the relationship between substance use and HIV risk behavior, but that alcohol expectancies did not (18). Specifically, alcohol use led to sexual risk behavior among men who endorsed drinking to enhance social interaction but not among men who did not, while drug use led to increased sexual risk behavior among men who intended to engage in safer sex but not among men who did not (18).

Indeed, the effects of substance use on sexual behavior are not necessarily homogeneous; they may be contingent on other factors. For example, expectancies about how alcohol will affect one's behavior have been shown to predict actual behavior when drinking (8, 10-15). In addition, not just what people expect to happen when they drink but their motives for drinking have also been found to influence the effects of alcohol (21). Reasons for drinking have also been found to

interact with other situational characteristics to influence levels of alcohol consumption (22).

Among MSM, reasons for drinking were found to influence how much men drink, although they were not found to have a direct effect on sexual risk behavior (23). Safer sex intentions are also important to consider as modifiers of the effect of substance use on sexual risk behavior because people who use condoms when they are not intoxicated also tend to use them when they are intoxicated, just as people who do not use condoms when they are not intoxicated tend to not use them when they are intoxicated (8).

One limitation to studies that have examined effect modification when looking at the relationship between substance use and sexual risk behavior (13, 15), including our own among black South African MSM,(18) is that they relied on general measures of substance use and sexual risk behavior over a specific time frame but without regard to their temporal overlap. More exact temporal data, such as event-level data, can be used to discern whether substances were used in close enough temporal proximity to engaging in sexual activity that it could influence this behavior (3, 4, 8). Event-level data additionally allows for simultaneous consideration of other important individual-, event- and partnership- level characteristics (24-26).

This paper used data from a specific sexual event to assess the direct effect between substance use and sexual risk behavior and then to assess effect modification of this relationship by alcohol expectancies, reasons for drinking and safer sex intentions. To investigate these issues, we used data from a study of black MSM from the metropolitan area of Tshwane (Pretoria), South Africa., a population with a heavy burden of substance use, sexually transmitted infections (self-reported) and HIV (27-29).

## Methods

### *Participants*

Black South African MSM were recruited using respondent-driven sampling (RDS) (30, 31), a strategy commonly used for populations that are difficult to include in research. RDS is preferable to convenience sampling because it helps improve the generalizability of the findings to the underlying population. Eligibility criteria included: age between 18 and 44; having engaged in oral, anal, or masturbatory sex with a man in the prior 12 months; living, working, or socializing in the Tshwane (Pretoria) metropolitan area; fluency in English, Sepedi (Northern Sotho), or Tswana (Setswana); and willingness to take a rapid HIV test. Consistent with RDS methodology, seed participants were purposively selected based on geographic place of residence and their potential to propagate large and diverse recruitment chains (27). Twenty seeds were selected and asked to distribute three to five recruitment coupons to eligible men from their social networks, defined as other men who have sex with men over the age of 18 who they know and would be willing to recruit into the study. All participants were linked using recruitment coupon identification numbers. Once men were enrolled in the study and completed study procedures, staff provided them with recruitment coupons for further distribution. Although not an eligibility requirement, the race/ethnicity of all seeds was Black as the focus of the study was on black South African MSM. Over three quarters of South Africans are Black. The racial/ethnic segregation demonstrated by the sample reflects the racial/ethnic segregation that continues to characterize much of South Africa. Further details regarding the methods for this study have been previously provided (27).

### *Procedures*

All participants completed a 90-minute interviewer-administered computer-assisted personal interview. All interviews were conducted in a private space, either the office of the Human Sciences Research Council in the center of Tswane (Pretoria) or in one of the surrounding townships, e.g., in a community health center, depending on the participant's preference.

Research staff involved in screening, interviewing, HIV testing, and instruction for participant recruitment were trained in a three-day session. All study participants received gift cards to be redeemed for purchase of products at a supermarket as primary incentive for their own participation, as well as an additional gift card for each successful referral to the study.

All study procedures were approved by the Institutional Review Board of the New York State Psychiatric Institute in the U.S. and the Research Ethics Committee of the Human Sciences Research Council in South Africa. Participants provided separate written informed consent for the survey and HIV testing components of the study. Study staff provided referrals for confirmatory HIV testing and counseling in the case of a positive test result, as well as mental health, or primary care services as indicated.

### *Measures*

Participants were asked about their last sexual event (LSE) that involved anal sex, including partnership characteristics such as how long ago they met their partner, where they met, their relationship to the partner, and other relational attributes: concordance in age, race, neighborhood, socioeconomic status, and gender expression. Participants were also asked questions regarding event-level characteristics of the sexual encounter, such as where it took place, whether it was in exchange for money or food, whether drugs or alcohol were used and whether condoms were used. All measures regarding the LSE were calculated as characteristics



of the partnership, for which there is precedent (24, 25), except for substance use for which we used respondent substance use as we are interested specifically in how the effect of this factor on sexual risk behavior was influenced by other individual-level constructs (i.e. reasons for consuming alcohol, expectancies about its effects, and intentions to engage in safer sex) which were collected only for the respondent. Unprotected anal intercourse (UAI) was defined as having participated in anal intercourse without the use of a condom at any time during the LSE. Scales were primarily those adapted for and previously validated in South Africa. The AUDIT-C uses 3 items: how often the respondent drinks, how many drinks the respondent consumes in a typical day of drinking, and how frequently the respondent drinks six or more drinks at a time. Of a maximum score of 12 on the AUDIT-C, a score of four or more indicates hazardous drinking for men (32, 33). The presence of a drug use problem over the past year was assessed using the 9-item Drug Abuse Screening Test (DAST) (33); (Cronbach's  $\alpha = 0.81$ ). A sample item is "Do you ever feel bad or guilty because of your drug use?" (Yes, No). Drug abuse was defined as answering yes to one or more items. The Sex-Related Alcohol Expectancy Scale (32, 33) was used to assess expectancies about the effects of alcohol use on sexual behavior, representing three domains: enhancement of sexual experience, increased sexual risk taking, and disinhibition of sexual behavior; ( $\alpha = 0.95$ ). A sample item is: "After a few drinks of alcohol I am more sexually responsive". Men replied on a 4-point Likert scale ("Strongly disagree" (1) - "Strongly agree" (4)). Additionally, men were asked about reasons for drinking related to enhancing social interaction (21). The two items used were: "How often did you drink because a drink helps you to relax around people?" and "How often did you drink because a drink helps you to have better sex?"; ( $\alpha = 0.80$ ). Men replied on a five point scale ("Never" (1) - "Always" (5)). Men who did not drink were assigned to "Never" (1) on all of these items. Three items were used to assess

intentions to engage in safer sex. Men were asked how likely it is that they will always use a condom when having insertive anal sex, when having receptive anal sex, and how likely it is they will discuss safer sex; ( $\alpha = 0.89$ ). Men replied on a 4-point scale (“Very Unlikely” (1) - “Very Likely” (4)). The survey also addressed demographic characteristics, including age, education and income.

### *Statistical analyses*

Since RDS was the method used for the recruitment of this sample, all data were adjusted prior to analyses using an RDS II estimator (34, 35). This approach gives greater weight to those participants with a small personal network size, since those men presumably would be less likely to be recruited into the study.

Tests to determine which variables were associated with UAI included t-tests for continuous and scaled variables and Chi-squared tests for dichotomous variables. Multivariable analyses were run using multiple logistic regression. Initially, a main effect between substance use and UAI was tested. Effect modification was then tested by adding multiplicative interaction terms for substance use and each hypothesized effect modifier to the regression model. If effect modification was identified, stratified multivariable analyses with all covariates were run among groups at low and high levels of the relevant modifying construct. Statistical tests were 2-sided and  $p < .05$  was considered statistically significant. SPSS 17.0 was used for all statistical analyses.

### **Results**

In total, 480 eligible participants were recruited in 18 waves between August 2011 and January 2013. Six men did not have data on the outcome variable (UAI at the LSE) and were excluded from all analyses. Most (56%) participants were less than 24 years old, more than half (53%) had completed high school, and 35% had a regular income (see Table 4.1).

Nearly a third (30%, n=139) of men reported that they used drugs or alcohol prior to their LSE. Of these 139 men, 89% screened positive as hazardous drinkers and 23% screened positive as having problematic drug use. One fifth (20%) of the sample reported engaging in unprotected anal intercourse (UAI) during the LSE. Nearly two thirds (66%) of men said the LSE occurred with a steady partner, with an even higher proportion (80%) occurring among men who had previously had sex with each other (see Table 4.2).

There was no difference in the frequency of UAI among men who used drugs or alcohol immediately prior to having sex (19%) compared to the frequency of UAI among men who had not used drugs or alcohol immediately prior to having sex (20%,  $p=.86$ ). There was a higher frequency of UAI among steady partners ( $p<.01$ ), partners who lived in the same neighborhood ( $p<.01$ ), and age-discordant couples ( $p<.001$ ). In multivariable analyses including all participants, and all individual-, partnership- and situational characteristics, substance use prior to the LSE did not have a main effect on UAI ( $p=.97$ ). Discordance in age (aOR=4.2, 95%CI=1.8-9.8,  $p<.01$ ) and partners living in the same neighborhood (aOR=1.8, 95%CI=1.0-3.1,  $p<.05$ ) were both independently associated with UAI.

Men who engaged in UAI during the LSE endorsed more statements regarding drinking to enhance social interaction ( $p<.01$ ), had higher expectancies about the effects of alcohol ( $p<.001$ ), and had lower intentions to engage in safer sex ( $p<.001$ ) (see Table 4.1).

Interaction terms for substance use and expectancies about its effects, reasons for consuming alcohol, and intentions to engage in safer sex were added to the multivariable model looking at the effect of substance use prior to the LSE on UAI. The effect of substance use prior to the LSE on UAI was modified by safer sex intentions ( $p<.01$ ) but not expectancies about the effects of alcohol ( $p=.66$ ) nor reasons for consuming alcohol ( $p=.15$ ) (see Table 4.3).

Given the observed effect modification by safer sex intentions, the sample was stratified into men with lower safer sex intentions (n=268) and men with higher safer sex intentions (n=206). UAI was more frequent among men with lower safer sex intentions (28%) than among men with higher safer sex intentions (9%) ( $p<.001$ ). In multivariable analyses controlling for individual-, partnership- and situational characteristics, substance use prior to the LSE was not associated with UAI ( $p=.06$ ) among those with lower safer sex intentions. Among those with higher safer sex intentions, substance use prior to the LSE was positively associated with UAI (aOR=5.8, 95%CI=1.6-21.3,  $p<.01$ ).

## **Discussion**

The purpose of this study was to use event-level data to assess if substance use increases sexual risk behavior among black South African MSM and whether the relationship between substance use and sexual risk behavior is modified by expectancies about the effects of alcohol, reasons for consuming alcohol, or intentions to engage in safer sex. We found that men who drank or used drugs prior to their last sexual encounter were not more likely to engage in risky sexual behavior than men who did not drink or use drugs prior to their last sexual encounter. Although we did not observe a main effect, we found that the effect of substance use on sexual risk behavior was modified by safer sex intentions. Among men with high intentions to engage in safer sex, men who drank or used drugs prior to their last sexual encounter were more likely to engage in risky sexual behavior.

Our findings demonstrating the modifying effects of safer sex intentions on the relationship between substance use and sexual risk behavior are in accordance with our findings from a previous study showing that drug use was associated with increased sexual risk behavior among men who intended to engage in safer sex but not among men who did not (18). Taken together,

these findings may help to explain inconsistencies in studies looking at substance use and sexual risk behavior (6-9), including among black South African MSM (28, 36). Varying distributions of other conditions needed for substance use to lead to increased sexual risk behavior (such as safer sex intentions) help explain why the relationship between substance use and sexual risk behavior has not always been observed (12, 37, 38).

Our finding that substance use was associated with increased sexual risk behavior only among those with higher safer sex intentions confirms that safer sex intentions are an important component of safer sex behavior.(39) As further testament to this, we also observed a strong negative association between safer sex intentions and sexual risk behavior in bivariate analyses. Efforts to reduce HIV risk behavior should focus on both increasing safer sex intentions and negating the impact of substance use on sexual risk behavior otherwise they may yield little benefit.

Further understanding of the determinants that lead to sexual risk behavior in this context of high HIV prevalence is important for informing HIV prevention efforts. Given the high HIV prevalence in this population and the variability in safer sex intentions, these men may have developed a sense of fatalism regarding HIV infection, a topic of some importance for future studies. Awareness of HIV status and perception of HIV risk were also low, with only a third (34.7%) of men having tested for HIV in the past 6 months and among HIV positive men in the sample, nearly half (48.3%) thought that it was unlikely or very unlikely that they were HIV-infected.(27)

Our finding that drinking or using drugs prior to having sex did not have a main effect on risky sexual behavior among the entire sample is in line with other studies that did not find a link between substance use and sexual risk behavior, including studies conducted in sub-Saharan

Africa,(6-8) but is in contrast to the large body of evidence suggesting that these behaviors are associated.(2-5) Our findings that reasons for drinking and expectancies about alcohol did not impact the relationship between alcohol use and sexual risk behavior are also in contrast to other research on the modifying effects of alcohol expectancies (10, 13-15, 17) and reasons for drinking.(18, 19) The high levels of substance use and UAI that we observed, despite the high prevalence of HIV infection and limited awareness of current HIV status among these men (18, 27) are also in accordance with what has been previously observed in this setting (27, 28, 36, 40).

There are certain limitations to the current study. First, drug and alcohol use prior to the sexual encounter could have been assessed with more precision. We assessed alcohol and drug use with one single item and were not able to distinguish between them. Given the prevalence of alcohol use compared to drug use among the men who reported drug or alcohol use prior to the last sexual encounter (96% of men drank alcohol in the past year while only 30% used drugs; only 1 man exclusively used drugs), we assume that alcohol use represents most substance use in this context. Furthermore, we think this likely represents hazardous alcohol use as 89% of the men who reported drug or alcohol use prior to the last sexual encounter screened positive as hazardous drinkers (23% reported problematic drug use). Future studies should distinguish between drug or alcohol use. The single-item measure that we used also did not collect information on the quantity or timing of the substance use. Given the varying physiological effects of different drugs and alcohol, with variation in physiological effects even within a particular substance depending on the timing and amount consumed, this would be helpful to take into account. Also, we did not include a measure of strategies that persons may employ to lower their risk of HIV that are not condom-based (e.g., strategic positioning) but instead

assumed that all UAI was sexual risk behavior. Our justification for this decision is that we considered any UAI in this situation to represent risk of HIV infection given the high prevalence of HIV and the low proportion of men who were aware of their HIV status.(41) Also, the scales used were almost exclusively developed in Western settings, and while all of them have previously been demonstrated to be reliable and valid, including many in South Africa, there may be additional culture-specific factors, such as social norms regarding substance use or sexual behavior, that have not been accounted for. Also, the study was conducted among black South African MSM and generalizability outside of that setting is unknown. Lastly, the data collected are self-reported and could have been subject to social desirability or recall bias. The current study contributes to a more complete understanding of substance use and its relationship to sexual risk behavior by demonstrating the moderating effects of safer sex intentions. Understanding more about the context in which substance use leads to sexual risk behavior is important information for identifying effective strategies for reducing HIV transmission among this critical population. Based on these findings, efforts to reduce HIV risk behavior should focus on both increasing safer sex intentions and negating the impact of substance use on sexual risk behavior otherwise they may yield little benefit. Given that South Africa has a high prevalence of hazardous drinking, a growing problem with drug use,(42) and the highest burden of HIV in the world, identifying and addressing factors that contribute to these public health problems and applying that knowledge is of critical importance.

## Tables

Table 4.1. Demographic characteristics and potential modifiers of the effect of substance use on sexual risk behavior by having engaged in unprotected anal intercourse (UAI) at last sexual encounter (LSE)

	Total		UAI		No UAI		$\chi^2$	<i>p</i>
	%	N	%	N	%	N		
<b>Demographic characteristics</b>								
<b>Age</b>							1.38	.241
23 or younger	56.3 %	267	21.7 %	58	78.3%	209		
24 or older	43.7 %	207	17.4 %	36	82.6%	171		
<b>Educational attainment</b>							3.06	.080
≤ Grade 12	47.3 %	224	23.2 %	52	76.8%	172		
> 12 Grade or diploma	52.7 %	250	16.8 %	42	83.2%	208		
<b>Income</b>							0.57	.452
No regular income	64.8 %	307	20.8 %	64	79.2%	243		
Regular income	35.2 %	167	18.0 %	30	82.0%	137		
<b>Potential effect modifiers<sup>1</sup></b>								
	M	SD	M	SD	M	SD	<i>t</i>	<i>p</i>
Expectancies about the effects of alcohol <sup>2</sup>	2.43	0.55	2.63	0.41	2.38	0.58	-3.89	<.001
Drink alcohol to enhance social interaction <sup>3</sup>	2.39	1.24	2.70	1.34	2.31	1.20	-2.75	<.01
Intentions to engage in safe sex <sup>2</sup>	3.23	0.67	2.71	0.79	3.36	0.57	8.99	<.001

1. Higher scores indicate higher levels of the construct. 2. Range: 1-4. 3. Range: 1-5



Table 4.2. Partnership and event characteristics of the last sexual encounter (LSE) by having engaged unprotected anal intercourse (UAI)

	Total		UAI		No UAI		$\chi^2$	<i>p</i>
	%	N	%	N	%	N		
<b>Partnership characteristics</b>								
<b>First time with that partner</b>							6.96	.008
Yes	20.4%	97	10.3%	10	89.7%	87		
No	79.6%	377	22.3%	84	77.7%	293		
<b>Steady partner</b>							7.07	.008
Yes	65.9%	313	23.3%	73	76.7%	240		
No	34.1%	162	13.0%	21	87.0%	140		
<b>Met through friends/colleagues</b>							0.46	.498
Yes	29.5%	139	18.0%	25	82.0%	114		
No	70.5%	333	20.7%	69	79.3%	264		
<b>Live in the same neighborhood</b>							7.13	.008
Yes	62.6%	297	23.6%	70	76.4%	227		
No	37.4%	177	13.5%	24	86.5%	154		
<b>Same age</b>							15.63	<.001
Yes	21.7%	103	5.9%	6	94.1%	96		
No	78.3%	371	23.5%	87	76.5%	284		
<b>Same race</b>							2.15	.142
Yes	93.5%	443	20.5%	91	79.5%	352		
No	6.5%	31	9.7%	3	90.3%	28		
<b>Same SES</b>							0.04	.839
Yes	18.7%	88	19.1%	17	80.9%	72		
No	81.3%	385	20.1%	77	79.9%	307		
<b>Same masculinity/femininity</b>							0.00	.985
Yes	4.3%	20	20.0%	4	80.0%	16		
No	95.7%	454	19.8%	90	80.2%	364		
<b>Event characteristics</b>								
<b>Sex took place at home</b>							0.73	.393
Yes	92.6%	439	20.3%	89	79.7%	350		
No	7.4%	35	14.3%	5	85.7%	30		
<b>Sex was transactional</b>							0.02	.880
Yes	7.9%	37	18.9%	7	81.1%	30		
No	92.1%	436	20.0%	87	80.0%	349		
<b>Respondent substance use</b>							0.03	.859
Yes	29.4%	139	19.3%	27	80.7%	113		
No	70.6%	335	20.0%	67	80.0%	268		

Table 4.3. Multivariable analyses looking at the effect of substance use on unprotected anal intercourse (UAI) at last sexual encounter (LSE) and potential effect modifiers

	aOR	95% CI	Wald	<i>p</i>
<b>Primary exposure</b>				
Respondent substance use	0.98	0.57-1.69	0.01	.95
<b>Potential effect modifiers</b>				
Expectancies about the effects of alcohol * Substance use			0.20	.66
Drink alcohol to enhance social interaction * Substance use			2.08	.15
Intentions to engage in safe sex * Substance use			11.91	<.01

1. Multivariable models included all individual-, partnership- and event-level characteristics as covariates.

## References

1. Schneider M, Chersich M, Neuman M, Parry C. Alcohol consumption and HIV/AIDS: the neglected interface. *Addiction* (Abingdon, England). 2012;107(8):1369-71.
2. Rehm J, Shield KD, Joharchi N, Shuper PA. Alcohol consumption and the intention to engage in unprotected sex: systematic review and meta-analysis of experimental studies. *Addiction* (Abingdon, England). 2012;107(1):51-9.
3. Kalichman SC, Simbayi LC, Kaufman M, Cain D, Jooste S. Alcohol use and sexual risks for HIV/AIDS in sub-Saharan Africa: Systematic review of empirical findings. *Prev Sci*. 2007;8(2):141-51.
4. Woolf-King SE, Maisto SA. Alcohol use and high-risk sexual behavior in Sub-Saharan Africa: a narrative review. *Archives of sexual behavior*. 2011;40(1):17-42.
5. Bryant KJ. Expanding research on the role of alcohol consumption and related risks in the prevention and treatment of HIV/AIDS. *Substance use & misuse*. 2006;41(10-12):1465-507.
6. Stall R, Purcell DW. Intertwining epidemics: a review of research on substance use among men who have sex with men and its connection to the AIDS epidemic. *AIDS Behav*. 2000;4(2):181-92.
7. Cooper ML. Does drinking promote risky sexual behavior? A complex answer to a simple question. *Curr Dir Psychol Sci*. 2006;15:19-23.
8. Weinhardt LS, Carey MP. Does alcohol lead to sexual risk behavior? Findings from event-level research. *Annual review of sex research*. 2000;11:125-57.
9. Sandfort T, Knox J, Alcala C, El-Bassel N, Kuo I, Smith L. Substance use and HIV risk among men who have sex with men in Africa: A systematic review. *J Acquir Immune Defic Syndr*. In Press.
10. Fromme K, D'Amico EJ, Katz EC. Intoxicated sexual risk taking: an expectancy or cognitive impairment explanation? *Journal of studies on alcohol*. 1999;60(1):54-63.
11. George WH, Stoner SA, Norris J, Lopez PA, Lehman GL. Alcohol expectancies and sexuality: a self-fulfilling prophecy analysis of dyadic perceptions and behavior. *Journal of Studies on Alcohol*. 2000;61:168-76.
12. George WH, Stoner SA. Understanding acute alcohol effects on sexual behavior. *Annual review of sex research*. 2000;11:92-124.
13. McKirnan DJ, Vanable PA, Ostrow DG, Hope B. Expectancies of sexual "escape" and sexual risk among drug and alcohol-involved gay and bisexual men. *Journal of substance abuse*. 2001;13(1-2):137-54.
14. Dermen KH, Cooper ML, Agocha VB. Sex-related alcohol expectancies as moderators of the relationship between alcohol use and risky sex in adolescents. *Journal of studies on alcohol*. 1998;59(1):71-7.
15. Bryan AD, Ray LA, Cooper ML. Alcohol use and protective sexual behaviors among high-risk adolescents. *J Stud Alcohol Drugs*. 2007;68(3):327-35.
16. Newcomb ME, Clerkin EM, Mustanski B. Sensation seeking moderates the effects of alcohol and drug use prior to sex on sexual risk in young men who have sex with men. *AIDS and behavior*. 2011;15(3):565-75.
17. Mustanski B. Moderating effects of age on the alcohol and sexual risk taking association: an online daily diary study of men who have sex with men. *AIDS and behavior*. 2008;12(1):118-26.

18. Knox J, Reddy V, Lane T, Hasin D, Sandfort T. Substance use and sexual risk behavior among black South African men who have sex with men: the moderating effects of reasons for drinking and safer sex intentions. *AIDS and behavior*. In Press.
19. Gordon CM, Carey MP, Carey KB. Effects of a drinking event on behavioral skills and condom attitudes in men: implications for HIV risk from a controlled experiment. *Health Psychol*. 1997;16(5):490-5.
20. Morojele NK, Kachieng'a MA, Mokoko E, Nkoko MA, Parry CD, Nkowane AM, et al. Alcohol use and sexual behaviour among risky drinkers and bar and shebeen patrons in Gauteng province, South Africa. *Social science & medicine*. 2006;62(1):217-27.
21. Golding JM, Burnam MA, Benjamin B, Wells KB. Reasons for drinking, alcohol use, and alcoholism among Mexican Americans and non-Hispanic Whites. *Psychol Addict Behav*. 1992;6(3):155-67.
22. Abbey A, Smith MJ, Scott RO. The relationship between reasons for drinking alcohol and alcohol consumption: an interactional approach. *Addictive behaviors*. 1993;18(6):659-70.
23. Feinstein BA, Newcomb ME. Event-level associations among drinking motives, alcohol consumption, and condomless anal sex in a sample of young men who have sex with men. *AIDS and behavior*. 2017.
24. Knox J, Reddy V, Kaighobadi F, Nel D, Sandfort T. Communicating HIV status in sexual interactions: assessing social cognitive constructs, situational factors, and individual characteristics among South African MSM. *AIDS and behavior*. 2013;17(1):350-9.
25. Sandfort T, Yi H, Knox J, Reddy V. Sexual partnership types as determinant of HIV risk in South African MSM: an event-level cluster analysis. *AIDS Behav*. 2013;17 Suppl 1:S23-32.
26. Colfax G, Vittinghoff E, Husnik MJ, McKirnan D, Buchbinder S, Koblin B, et al. Substance use and sexual risk: a participant- and episode-level analysis among a cohort of men who have sex with men. *American journal of epidemiology*. 2004;159(10):1002-12.
27. Sandfort TG, Lane T, Dolezal C, Reddy V. Gender expression and risk of HIV infection among black South African men who have sex with men. *AIDS and behavior*. 2015;19(12):2270-9.
28. Lane T, Raymond HF, Dladla S, Rasethe J, Struthers H, McFarland W, et al. High HIV prevalence among men who have sex with men in Soweto, South Africa: results from the Soweto Men's Study. *AIDS and behavior*. 2011;15(3):626-34.
29. Burrell E, Mark D, Grant R, Wood R, Bekker LG. Sexual risk behaviours and HIV-1 prevalence among urban men who have sex with men in Cape Town, South Africa. *Sex Health*. 2010;7(2):149-53.
30. Heckathorn DD. Respondent-driven sampling: A new approach to the study of hidden populations. *Social Problems*. 1997;44(2):174-99.
31. Heckathorn DD, Semaan S, Broadhead RS, Hughes JJ. Extensions of respondent-driven sampling: a new approach to the study of injection drug users aged 18-25. *AIDS Behav*. 2002;6(1):55-67.
32. Dermen KH, Cooper ML. Sex-related alcohol expectancies among adolescents: II. Prediction of drinking in social and sexual situations. *Psychol Addict Behav*. 1994;8(3):161-8.

33. Dermen KH, Cooper ML. Sex-related alcohol expectancies among adolescents: I. Scale development. *Psychol Addict Behav.* 1994;8(3):152-60.
34. Salganik MJ, Heckathorn DD. Sampling and estimation in hidden populations using respondent driven sampling. *Sociol Methodol.* 2004;34(1):193-240.
35. Volz E, Heckathorn DD. Probability based estimation theory for respondent driven sampling. *J Off Stat.* 2008;24(1):79-97.
36. Lane T, Shade SB, McIntyre J, Morin SF. Alcohol and sexual risk behavior among men who have sex with men in South african township communities. *AIDS and behavior.* 2008;12(4 Suppl):S78-85.
37. Steele CM, Josephs RA. Alcohol myopia. its prized and dangerous effects. *The American psychologist.* 1990;45(8):921-33.
38. Dingle GA, Oei TP. Is alcohol a cofactor of HIV and AIDS? Evidence from immunological and behavioral studies. *Psychological bulletin.* 1997;122(1):56-71.
39. Fisher JD, Fisher WA. Changing AIDS-risk behavior. *Psychological bulletin.* 1992;111(3):455-74.
40. Rispel LC, Metcalf CA, Cloete A, Reddy V, Lombard C. HIV prevalence and risk practices among men who have sex with men in two South African cities. *J Acquir Immune Defic Syndr.* 2011;57(1):69-76.
41. Sandfort T, Yi H, Knox J, Reddy V. Sexual partnership types as determinant of HIV risk in South African MSM: an event-level cluster analysis. *AIDS and behavior.* 2012.
42. Pasche S, Myers B. Substance misuse trends in South Africa. *Human psychopharmacology.* 2012;27(3):338-41.

## **Chapter 5 CONCLUSION**

### **Background**

The goal of this dissertation was to assess determinants of hazardous drinking and explore the relationship between substance use and HIV risk behavior among black South African MSM with a focus on the role of social networks. This is an area of interest because Black South African MSM face a set of circumstances that put them at an elevated risk for hazardous drinking and HIV infection. Social networks are also presumed to be of heightened importance among black South African MSM because of the limited ways that they can interact in a setting where same-sex sexuality is highly stigmatized (1-6) and there is no commercial gay subculture (e.g. gay friendly bars and clubs). Addressing these aims was further motivated by 1) the lack of a previous systematic review of the literature describing the influence of social network characteristics among adults; 2) the lack of evidence identifying determinants of hazardous drinking among an South African MSM population despite the known heavy burden of alcohol use in many of these populations; and 3) inconsistencies in reports on the relationship between alcohol use and sexual risk behavior. A comprehensive, systematic review of the literature was conducted to evaluate whether social network characteristics have been shown to influence adults' drinking behaviors, both in terms of characteristics of their network structures and characteristics of their network ties. This review helped establish the importance of social network characteristics with regards to alcohol use among adults. I then conducted an empirical assessment of determinants of hazardous drinking, which included individual psychosocial risk factors and social network characteristics. Finally, I conducted an analysis of whether substance use predicts HIV risk behavior during a defined sexual encounter, including whether the relationship between substance use and HIV risk behavior is modified by reasons for substance

use, expectations about their effect on sexual behavior, and safe sex intentions. Below, the primary results are summarized and implications are discussed.

### **Summary of Results**

For the review in Chapter 2, 18 studies were identified and evaluated to determine how social network analysis methodologies had been applied to empirical data to investigate alcohol consumption among adult populations. Overall, these studies found that characteristics of one's peers as well as social network structure influenced people's alcohol consumption in a variety of ways and across settings. Studies that explored the homophily (i.e. the phenomenon that individuals choose to befriend others who are like them) of social networks observed that members of a shared social network became more alike over time in terms of drinking (7, 8) and that selection and induction were both likely contributing factors (8, 9). These results suggest that social network effects, including both peer characteristics and social structure, influence alcohol consumption among adults.

For the empirical analyses in Chapter 3, Black South African MSM were found to have high levels of alcohol use; nearly two thirds of them screened positive as hazardous drinkers. Various factors were found to increase men's likelihood of being hazardous drinkers. Men who live in a township (versus the city of Pretoria), men with higher levels of gender dysphoria, men who had ever received money or other incentives in return for sex, men who had been sexually abused as a child, and men with anxiety were all more likely to be hazardous drinkers. Men who reported being sexually attracted only to men were less likely to be hazardous drinkers. Men whose social networks included a higher proportion of hazardous drinkers were more likely to be hazardous drinkers themselves. The high levels of alcohol use found in the current study are comparable to what has been described in other studies conducted among black South African MSM (10-12).

That indicators of social vulnerability were found to increase men's likelihood of being hazardous drinkers is similar to what has been found in other studies (13-17). Indicators of social vulnerability have also been found to be predictors of other risk behaviors among black South African MSM (18-21). These findings heighten concern because of how these co-occurring health problems work synergistically to increase risk of HIV infection (22, 23).

For the empirical analyses in Chapter 4, event-level data was used to assess if substance use increases sexual risk behavior among black South African MSM, and whether the relationship between substance use and sexual risk behavior is modified by expectancies about the effects of alcohol, reasons for consuming alcohol, or intentions to engage in safer sex. I found that men who drank or used drugs prior to their last sexual encounter were not more likely to engage in risky sexual behavior. Although I did not observe a main effect, we found that the effect of substance use on sexual risk behavior was modified by safer sex intentions. Among men with high intentions to engage in safer sex, men who drank or used drugs prior to their last sexual encounter were more likely to engage in risky sexual behavior. My finding that drinking or using drugs prior to having sex did not have a main effect on risky sexual behavior among the entire sample is in line with other studies that did not find a link between substance use and sexual risk behavior, including studies conducted in sub-Saharan Africa,(24-26) but is in contrast to the large body of evidence suggesting that these behaviors are associated.(27-30) My findings that reasons for drinking and expectancies about alcohol did not impact the relationship between alcohol use and sexual risk behavior are in contrast to other research on the modifying effects of alcohol expectancies (31-35) and reasons for drinking.(36, 37) The high levels of substance use and UAI that were observed, despite the high prevalence of HIV infection and limited awareness



of current HIV status among these men (37, 38) are also in accordance with what has been previously observed in this setting (12, 38-40).

### **Limitations and Strengths**

The analyses presented in this dissertation have several limitations. First, the systematic review conducted in Chapter 2 has limitations both in terms of the study results that it summarizes and in terms of the review itself. First, only 18 studies were identified and deemed eligible to be included based on relevance and quality. This is likely because the use of social network analysis to study alcohol use among adults is much more challenging than studying peer effects among other age groups (i.e. adolescents), where social network data is easier to collect and peer effects seemingly more salient. The limited number of articles could also be because the use of social network methods was not indicated in the title or abstract and thus they would not have been identified during the literature search. Second, the results of social network analysis studies are context specific, and insights are likely to vary based on setting and the exposures and outcomes that were measured. Attempts to synthesize across the included studies were difficult given their heterogeneity. The empirical analyses conducted for Chapters 3 & 4 also had their own limitations. For both, the cross-sectional research design limits the ability to infer causality. Both analyses were conducted among black South African MSM and may have limited generalizability outside of that setting. The constructs used were almost exclusively developed in Western settings, and while many of them have previously been demonstrated to be reliable and valid, including in South Africa, there may be additional culture-specific factors that have not been accounted for. Lastly, the data collected are self-reported and could have been subject to social desirability or recall bias. Specific to Chapter 3, an additional limitation is that data was not available regarding being on treatment for HIV. Given how few men knew their current HIV

status, the limited availability of antiretroviral therapy (ART) during the study period and the criteria for starting treatment at the time, I suspect that few men were on ART. Specific to Chapter 4, additional limitations are that alcohol and drug use in association with engaging in sex using were assessed using one single item and I was not able to distinguish between them. Also, the data did not include a measure of strategies that persons may employ to lower their risk of HIV that are not condom-based (e.g., strategic positioning); instead I assumed that all UAI was sexual risk behavior.

Notwithstanding these limitations, this dissertation has many important strengths. Chapter 2 provides a systematic review of the literature on a topic that has received attention through empirical investigations but which has not been systematically reviewed. Chapters 3 is the first analysis to identify risk factors for hazardous drinking (41) among a population that is known to be disproportionately affected by this problem (38-40, 42). In doing so, I not only considered a rich set of psychosocial factors that were available in the data but I also utilized data on men's social networks. Chapter 4 improved upon previous analyses examining substance use and sexual risk behavior among black South African MSM by applying more temporal precision and additionally considering other situational- and relationship-characteristics (42). Chapters 3 & 4 both contributed important findings regarding substance use and HIV infection among an understudied and underserved population. While black South African MSM are an important minority sample in their own right, they are of additional importance in this case because valuable insight can be gained by focusing on this minority population. At times, certain processes are magnified among minority populations and we can see things more clearly that are otherwise harder to recognize in broader population studies. For example, in some contexts there may be an increased level of risk, but most studies will not encounter a high enough proportion

of people who experience this particular context in order for its effect to become illuminated. Or certain minority populations, such as black South African MSM, may have more variability in their levels of alcohol consumption or their intentions to engage in safe sex that allow us to see how these characteristics might influence other behaviors, such as the influence of substance use on HIV risk behavior. By studying populations such as black South African MSM, we learn about the potential risk of these contexts that gives us more information about that context, and not just about the minority population. In this sense, this dissertation contributes to a greater understanding about the determinants of hazardous drinking and HIV risk behavior, more generally. This was considered in the interpretation of my findings.

### **Implications and Future Directions**

The findings from this dissertation have several important implications for interventions that address hazardous drinking and limiting ongoing HIV transmission and for future studies on substance use and HIV risk among black South African MSM.

With regards to interventions, the review conducted in Chapter 2 found that social networks influence alcohol use and that social network analysis remains a powerful tool with the potential to explore these effects. The fact that relatively few studies were identified that have used social network analysis to study alcohol consumption among adult populations suggests that these approaches are underutilized. Chapter 3 provides further evidence of the severity of excessive alcohol use among black South African MSM and that efforts aimed at reducing hazardous drinking are greatly needed. Various determinants of hazardous drinking were identified, including many indicators of social vulnerability. The findings are of concern because these health problems often work synergistically to increase risk of HIV infection (22, 23). The drinking habits of men's social network ties also was highly correlated with men's own drinking

habits. These findings should be taken into consideration by efforts aimed at reducing hazardous drinking among this critical population. Specifically, intervention strategies should consider targeting MSM who are the most vulnerable, those who live in townships, who have had to engage in sex for money or favors, who have a history of childhood sexual abuse or who suffer from other mental health problems. Possible interventions might include those that not only target individuals but their social networks (43). Chapter 4 contributes to a more complete understanding of substance use and its relationship to sexual risk behavior by demonstrating the moderating effects of safer sex intentions. Understanding more about the context in which substance use leads to sexual risk behavior is important for identifying effective strategies for reducing HIV transmission among this critical population. Based on my findings, efforts to reduce HIV risk behavior should focus on both increasing safer sex intentions and negating the impact of substance use on sexual risk behavior otherwise they may yield little benefit.

This dissertation also has several implications for future research studies. The findings from the review conducted in Chapter 2 can be used to inform researchers about structures and characteristics of social networks among adults, their role in the spread of alcohol use, and the potential for interventions that utilize pre-existing social networks to help reduce the burden of harmful alcohol consumption. Future studies that use social network analysis could agree to use a more standardized set of methods so that they are comparable across studies. They could also make an increased effort to learn about non-college adults, those at the same age who are not in college, and those past the typical college age. Chapter 3 identified numerous factors that increased men's likelihood of being hazardous drinkers, although many potential risk factors were not found to be associated with hazardous drinking. This speaks to the exploratory nature of these analyses, given the lack of previous research among African MSM populations, as well as

the complexity of substance use and psychosocial health among men in this setting (44-46). These issues merit further exploration. Chapter 4 contributes to a more complete understanding of substance use and its relationship to sexual risk behavior by demonstrating the moderating effects of safer sex intentions. Future research studies could improve upon my analyses by distinguishing between alcohol and drug use prior to a specific sexual encounter. Future studies should also explore the variability I observed in safer sex intentions, including whether black South African MSM may have developed a sense of fatalism regarding HIV infection. Finally, future studies should explore other potential sources of effect modification, as well as other factors that potentially contribute to inconsistencies among research studies assessing the association between substance use and HIV risk behavior, such as the heterogeneity in measures used to assess substance use and HIV risk behavior.

In conclusion, this dissertation increased our understanding of social networks, substance use and HIV risk behavior among black South African MSM. A recent review demonstrating the paucity of research on interventions directed at substance use and HIV risk among these men and other critical, African MSM populations attests to the urgent need for information to inform potential interventions (41). The review in Chapter 2 suggests the importance of using pre-existing social networks to deliver potential interventions. The empirical analyses in Chapter 3 suggest that the most vulnerable members of this community are at increased risk and should be targeted. The empirical analyses in Chapter 4 suggest that efforts to reduce HIV risk behavior should focus on both increasing safer sex intentions and negating the impact of substance use on sexual risk behavior. Taken together, these studies provide insight for developing potential interventions. Specifically, interventions that use social network data to facilitate behavioral change appear to be warranted (43). Network interventions include opinion leader interventions (47-49), where

influential members of a social network are used to disseminate behavior change messages, or using other more strategically located members to diffuse behavior change messages through a social network (50). When considering social network approaches to designing an intervention, it is important to note that social network interventions are not a one-size-fits-all model, but that they depend on the goals and objectives for that intervention (43). Given that South Africa has a high prevalence of hazardous drinking (10-12), a growing problem with drug use (47), and the highest burden of HIV in the world (48), efforts to address these public health problems are desperately needed.

## References

1. Niang CI, Tapsoba P, Weiss E, Diagne M, Niang Y, Moreau AM, et al. 'It's raining stones': stigma, violence and HIV vulnerability among men who have sex with men in Dakar, Senegal. *Cult Health Sex.* 2003;5(6):499-512.
2. van Griensven F. Men who have sex with men and their HIV epidemics in Africa. *AIDS.* 2007;21(10):1361-2 10.097/QAD.0b013e328017f868.
3. van Griensven F, Sanders EJ. Understanding HIV risks among men who have sex with men in Africa. *Sexually Transmitted Diseases.* 2008;35(4):355-6.
4. Smith AD, Tapsoba P, Peshu N, Sanders EJ, Jaffe HW. Men who have sex with men and HIV/AIDS in sub-Saharan Africa. *Lancet.* 2009;374(9687):416-22.
5. Adam PCG, de Wit JBE, Toskin I, Mathers BM, Nashkhoev M, Zablotska I, et al. Estimating levels of HIV testing, HIV prevention coverage, HIV knowledge, and condom use among men who have sex with men (MSM) in low-income and middle-income countries. *J Acquir Immune Defic Syndr.* 2009;52:S143-S51.
6. Muraguri N, Temmerman M, Geibel S. A decade of research involving men who have sex with men in sub-Saharan Africa: current knowledge and future directions. *SAHARA J.* 2012;9(3):137-47.
7. Phua J. The influence of peer norms and popularity on smoking and drinking behavior among college fraternity members: a social network analysis. *Social Influence.* 2011;6(3):153-68.
8. Rosenquist JN, Murabito J, Fowler JH, Christakis NA. The spread of alcohol consumption behavior in a large social network. *Annals of internal medicine.* 2010;152(7):426-33, w141.
9. Andrews JA, Tildesley E, Hops H, Li F. The influence of peers on young adult substance use. *Health Psychol.* 2002;21(4):349-57.
10. Lane T, Shade SB, McIntyre J, Morin SF. Alcohol and sexual risk behavior among men who have sex with men in South african township communities. *AIDS Behav.* 2008;12(4 Suppl):S78-85.
11. Lane T, Raymond HF, Dladla S, Rasethe J, Struthers H, McFarland W, et al. High HIV prevalence among men who have sex with men in Soweto, South Africa: results from the Soweto Men's Study. *AIDS Behav.* 2011;15(3):626-34.
12. Rispel LC, Metcalf CA, Cloete A, Reddy V, Lombard C. HIV prevalence and risk practices among men who have sex with men in two South African cities. *J Acquir Immune Defic Syndr.* 2011;57(1):69-76.
13. Rosario M, Schrimshaw EW, Hunter J. A model of sexual risk behaviors among young gay and bisexual men: longitudinal associations of mental health, substance abuse, sexual abuse, and the coming-out process. *AIDS education and prevention : official publication of the International Society for AIDS Education.* 2006;18(5):444-60.
14. McKirnan DJ, Peterson PL. Psychosocial and cultural factors in alcohol and drug abuse: an analysis of a homosexual community. *Addictive behaviors.* 1989;14(5):555-63.
15. Stall R, Paul JP, Greenwood G, Pollack LM, Bein E, Crosby GM, et al. Alcohol use, drug use and alcohol-related problems among men who have sex with men: the Urban Men's Health Study. *Addiction (Abingdon, England).* 2001;96(11):1589-601.

16. Diaz RM, Morales ES, Bein E, Dilan E, Rodriguez RA. Predictors of sexual risk in latino gay/bisexual men: the role of demographic, developmental, social cognitive, and behavioral variables. *Hisp J Behav Sci.* 1999;21(4):480-501.
17. Paul JP, Catania J, Pollack L, Stall R. Understanding childhood sexual abuse as a predictor of sexual risk-taking among men who have sex with men: The Urban Men's Health Study. *Child abuse & neglect.* 2001;25(4):557-84.
18. Knox J, Reddy V, Kaighobadi F, Nel D, Sandfort T. Communicating HIV status in sexual interactions: assessing social cognitive constructs, situational factors, and individual characteristics among South African MSM. *AIDS Behav.* 2013;17(1):350-9.
19. Knox J, Yi H, Reddy V, Maimane S, Sandfort T. The fallacy of intimacy: sexual risk behaviour and beliefs about trust and condom use among men who have sex with men in South Africa. *Psychol Health Med.* 2010;15(6):660-71.
20. Sandfort T, Yi H, Knox J, Reddy V. Sexual partnership types as determinant of HIV risk in South African MSM: an event-level cluster analysis. *AIDS Behav.* 2013;17 Suppl 1:S23-32.
21. Knox J, Sandfort T, Yi H, Reddy V, Maimane S. Social vulnerability and HIV testing among South African men who have sex with men. *Int J STD AIDS.* 2011:709-13.
22. Jie W, Ciyong L, Xueqing D, Hui W, Lingyao H. A syndemic of psychosocial problems places the MSM (men who have sex with men) population at greater risk of HIV infection. *PloS one.* 2012;7(3):e32312.
23. Stall R, Mills TC, Williamson J, Hart T, Greenwood G, Paul J, et al. Association of co-occurring psychosocial health problems and increased vulnerability to HIV/AIDS among urban men who have sex with men. *Am J Public Health.* 2003;93(6):939-42.
24. Stall R, Purcell DW. Intertwining epidemics: a review of research on substance use among men who have sex with men and its connection to the AIDS epidemic. *AIDS Behav.* 2000;4(2):181-92.
25. Weinhardt LS, Carey MP. Does alcohol lead to sexual risk behavior? Findings from event-level research. *Annual review of sex research.* 2000;11:125-57.
26. Cooper ML. Does drinking promote risky sexual behavior? A complex answer to a simple question. *Curr Dir Psychol Sci.* 2006;15:19-23.
27. Rehm J, Shield KD, Joharchi N, Shuper PA. Alcohol consumption and the intention to engage in unprotected sex: systematic review and meta-analysis of experimental studies. *Addiction (Abingdon, England).* 2012;107(1):51-9.
28. Kalichman SC, Simbayi LC, Kaufman M, Cain D, Jooste S. Alcohol use and sexual risks for HIV/AIDS in sub-Saharan Africa: Systematic review of empirical findings. *Prev Sci.* 2007;8(2):141-51.
29. Bryant KJ. Expanding research on the role of alcohol consumption and related risks in the prevention and treatment of HIV/AIDS. *Substance use & misuse.* 2006;41(10-12):1465-507.
30. Woolf-King SE, Maisto SA. Alcohol use and high-risk sexual behavior in Sub-Saharan Africa: a narrative review. *Archives of sexual behavior.* 2011;40(1):17-42.
31. Dermen KH, Cooper ML, Agocha VB. Sex-related alcohol expectancies as moderators of the relationship between alcohol use and risky sex in adolescents. *Journal of studies on alcohol.* 1998;59(1):71-7.
32. Bryan AD, Ray LA, Cooper ML. Alcohol use and protective sexual behaviors among high-risk adolescents. *J Stud Alcohol Drugs.* 2007;68(3):327-35.



33. McKirnan DJ, Vanable PA, Ostrow DG, Hope B. Expectancies of sexual "escape" and sexual risk among drug and alcohol-involved gay and bisexual men. *Journal of substance abuse*. 2001;13(1-2):137-54.
34. Fromme K, D'Amico EJ, Katz EC. Intoxicated sexual risk taking: an expectancy or cognitive impairment explanation? *Journal of studies on alcohol*. 1999;60(1):54-63.
35. Mustanski B. Moderating effects of age on the alcohol and sexual risk taking association: an online daily diary study of men who have sex with men. *AIDS and behavior*. 2008;12(1):118-26.
36. Gordon CM, Carey MP, Carey KB. Effects of a drinking event on behavioral skills and condom attitudes in men: implications for HIV risk from a controlled experiment. *Health Psychol*. 1997;16(5):490-5.
37. Knox J, Reddy V, Lane T, Hasin D, Sandfort T. Substance use and sexual risk behavior among black South African men who have sex with men: the moderating effects of reasons for drinking and safer sex intentions. *AIDS and behavior*. In Press.
38. Sandfort TG, Lane T, Dolezal C, Reddy V. Gender expression and risk of HIV infection among black South African men who have sex with men. *AIDS and behavior*. 2015;19(12):2270-9.
39. Lane T, Raymond HF, Dladla S, Rasethe J, Struthers H, McFarland W, et al. High HIV prevalence among men who have sex with men in Soweto, South Africa: results from the Soweto Men's Study. *AIDS and behavior*. 2011;15(3):626-34.
40. Lane T, Shade SB, McIntyre J, Morin SF. Alcohol and sexual risk behavior among men who have sex with men in South african township communities. *AIDS and behavior*. 2008;12(4 Suppl):S78-85.
41. Sandfort T, Knox J, Alcalá C, El-Bassel N, Kuo I, Smith L. Substance use and HIV risk among men who have sex with men in Africa: A systematic review. *J Acquir Immune Defic Syndr*. In Press.
42. Knox J, Reddy V, Lane T, Hasin D, Sandfort T. Substance Use and Sexual Risk Behavior Among Black South African Men Who Have Sex With Men: The Moderating Effects of Reasons for Drinking and Safer Sex Intentions. *AIDS and behavior*. 2017;21(7):2023-32.
43. Valente TW. Network interventions. *Science*. 2012;337(6090):49-53.
44. Sandfort TG, Lane T, Dolezal C, Reddy V. Gender expression and risk of HIV infection among black South African men who have sex with men. *AIDS Behav*. 2015;19(12):2270-9.
45. Cook SH, Sandfort TG, Nel JA, Rich EP. Exploring the relationship between gender nonconformity and mental health among black South african gay and bisexual men. *Archives of sexual behavior*. 2013;42(3):327-30.
46. Sandfort T, Bos H, Knox J, Reddy V. Gender nonconformity, discrimination, and mental health among black South African men who have sex with men: a further exploration of unexpected findings. *Archives of sexual behavior*. 2016;45(3):661-70.
47. Pasche S, Myers B. Substance misuse trends in South Africa. *Human psychopharmacology*. 2012;27(3):338-41.
48. Joint United Nations Programme on HIV/AIDS. Global report : UNAIDS report on the global AIDS epidemic. Geneva, Switzerland: Joint United Nations Programme on HIV/AIDS; 2012. p. v.