

MENTAL HEALTH AND SEXUAL RISK BEHAVIORS AMONG SOCIAL NETWORKS OF YOUNG TANZANIAN
MEN

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ABSTRACT

Lauren M. Hill: Mental Health and Sexual Risk Behaviors Among Social Networks of Young Tanzanian Men
(Under the direction of Suzanne Maman)

Background: Young men are important targets in HIV prevention in Tanzania and throughout sub-Saharan Africa. Anxiety and depression are common among youth and may be important predictors of HIV risk behaviors. Evidence of these relationships in high-risk populations is needed, as is understanding of how normative and supportive elements of the social environment might be leveraged to buffer the risk posed by poor mental health.

Methods: I conducted two studies using baseline and one-year follow-up data from 1113 sexually active male participants in an ongoing HIV and intimate partner violence prevention trial taking place among 59 social groups known as “camps” in Dar es Salaam, Tanzania. In the first study, I assessed the relationship between mental health (anxiety, depression) and sexual risk behaviors (condom use, concurrency) using multilevel modeling. In the second study, I built upon these models to test the moderating role of sexual behavior norms, camp network social cohesion, and men’s network centrality in the relationship between mental health and sexual risk behaviors. I further assessed peer behavioral influence in men’s camp friendship networks using quadratic assignment procedures.

Results: Both anxiety and depression were independently associated with concurrency but only depression was independently associated with condom use. In the second study, changes in perceived descriptive norms were associated with both condom use and concurrency, perceived injunctive norms were associated with concurrency, and direct encouragement was associated with condom use.

Changes in condom use norms (perceived descriptive norms and encouragement) moderated the relationship between changes in anxiety symptoms and condom use such that the negative relationship was amplified with worsening norms for condom use, and attenuated by improving norms for condom use. Network centrality and cohesion were not significantly related to sexual risk, nor did they interact with anxiety or depression in relation to sexual risk.

Conclusions: The results of this dissertation indicate the importance of screening and providing treatment for depression and anxiety in high HIV-prevalence contexts, and the need to develop effective HIV prevention interventions targeting young men living with anxiety and depression. Such interventions may benefit from the combination of norms-based and mental health promotion approaches.

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LIST OF ABBREVIATIONS

AIDS	Acquired immune deficiency syndrome
aOR	Adjusted odds ratio
CAPI	Computer assisted personal interviewing
CI	Confidence interval
EMA	Ecological momentary assessment
GIS	Geographic information system
GPS	Global positioning system
HIV	Human immunodeficiency virus
HSCL-25	Hopkins Symptom Checklist-25
ICC	Intra-class correlation
IRB	Institutional Review Board
N/No.	Number
OR	Odds ratio
PI	Principal Investigator
PLACE	Priorities for Local AIDS Control Efforts
PLHIV	People living with HIV
QAP	Quadratic assignment procedure
SD	Standard deviation
SES	Socioeconomic status
STI	Sexually transmitted infection
UNC	University of North Carolina
US	United States
USAID	United States Agency for International Development

CHAPTER 1: INTRODUCTION

1.1 Problem statement

Youth in Tanzania are disproportionately affected by HIV [1], and men are important targets in preventing HIV among Tanzanian youth [1]. Seven percent of the population of Tanzania's commercial capital, Dar es Salaam, is living with HIV [2], and youth are particularly vulnerable to infection with 40 percent of new infections in Tanzania occurring among 16-24 year olds [1]. An estimated 17 percent of females and 8 percent of males ages 15-19 in Tanzania are living with HIV [3]. Men are important targets in HIV prevention as they report higher rates than women of sexual risk behaviors including sexual partner concurrency and inconsistent condom use [1]. Half of sexually active male youth (ages 15-24) surveyed in Tanzania in 2010 did not use a condom at last intercourse [4]. Further, nearly one third of young men in Tanzania reported concurrent sexual relationships in 2010 [4], making condom use and concurrency important target risk behaviors in this population.

Anxiety and depression have been identified as important predictors of sexual risk [5-10], but we have little understanding of these relationships beyond cross-sectional associations, particularly in the sub-Saharan context. Cross-sectional associations have repeatedly been found between both anxiety and depression, and sexual risk behaviors (condom use and concurrency) [5-10], but we need more longitudinal evidence of these relationships to clarify the temporality and causality of these relationships. Further, the bulk of the evidence supporting these relationships comes from the United States and other high resource contexts [5, 8, 10-15]. Therefore, we need better evidence of the nature

of the relationship between mental health and sexual risk in the sub-Saharan context. The dissertation research serves to fill this gap in the literature.

We know little about the role that social networks play in shaping the relationship between mental health and sexual risk. Previous social network studies indicate that peers' mental health status affects an individual's own mental health [16, 17], and the same holds true for sexual risk behaviors [18]. However, we have little understanding of the potential influence of peers in patterns of mental health and sexual risk within the same network. Understanding peer influence on the relationship between mental health and sexual risk in young men's social networks will allow us to discern if there is something social or learned about sexual risk as a response to poor mental health. Lastly, we know little about how we may be able to intervene within networks to reduce sexual risk. The dissertation research aimed to address this gap in our knowledge by examining potential social network characteristics that buffer in the relationship between mental health and sexual risk behaviors.

1.2 Study purpose

The proposed research furthers our understanding of social and psychological determinants of HIV risk in a population of high risk young men by addressing three major gaps in the literature: a lack of evidence of the temporality of the relationship between mental health and sexual risk in this context, a particular lack of evidence of the connection between anxiety and sexual risk, and a lack of understanding of social network influences on the relationship between mental health and sexual risk.

1.3 Research approach

To address these gaps in the literature, I conducted a longitudinal study of the relationship between mental health (anxiety and depression) and sexual risk behaviors (condom use and sexual partner

concurrency). This study was completed using data from 1113 sexually active male participants taken from the baseline and one year follow-up assessments from the parent trial: *A Multilevel Intervention to Reduce HIV Risk Among Networks of Men in Tanzania* (PI: Suzanne Maman; 1R01MH098690-01). The dissertation Aims were completed using multilevel modeling and social network analysis.

Specific Aims

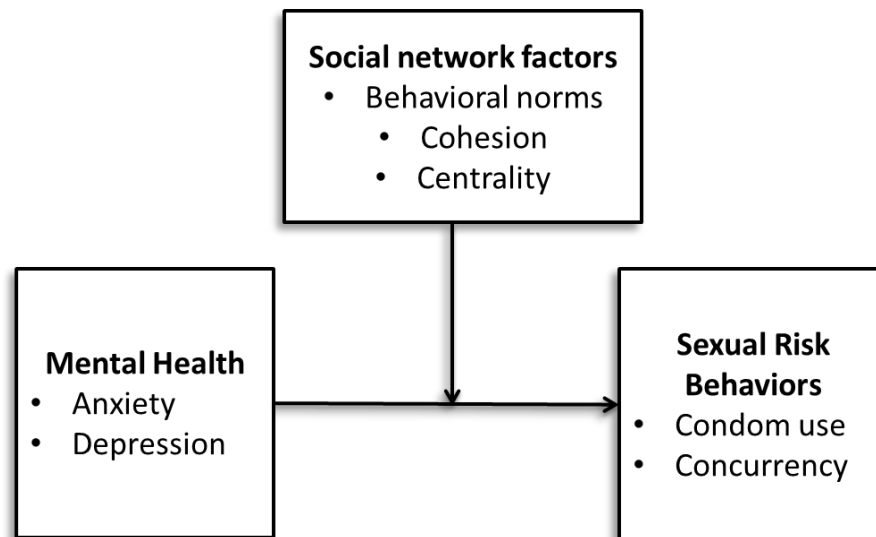


Figure 1. Conceptual model of hypotheses

The three Specific Aims of the dissertation research and their corresponding hypotheses were as follows:

Aim 1: Evaluate the longitudinal relationship between mental health (anxiety, depression) and sexual risk behaviors (condom use, concurrency) among young men.

Hypothesis 1: *Young men experiencing increased symptoms of anxiety and depression from time 1 to time 2 will report less frequent condom use and be more likely to report engaging in sexual*

partner concurrency at time 2, controlling for time 1 behaviors, than young men experiencing decreased symptoms of anxiety and depression.

Aim 2: Assess the level of social influence on young men's sexual risk behaviors, and the moderating role of social norms in the relationship between mental health and sexual risk behaviors within camp networks.

Hypothesis 2a: *Young men's sexual risk behaviors will be more correlated with those of friends than with those of other members of their camp network.*

Hypothesis 2b: *The relationship between mental health and sexual risk will be moderated by peer sexual risk behavior norms such that the relationship will be stronger for young men exposed to riskier peer norms than for men exposed to less risky peer norms.*

Aim 3: Test social network characteristics (centrality, social cohesion) as moderators of the relationship between mental health and sexual risk behaviors.

Hypothesis 3a: *Young men's centrality within their camp social network will moderate the relationship between mental health and sexual risk behaviors such that the relationship will be weaker for men with higher centrality than for those with lower centrality.*

Hypothesis 3b: *Network social cohesion will moderate the relationship between mental health and sexual risk behaviors such that the relationship will be weaker for young men in camps with higher levels of social cohesion than for those in camps with lower levels of social cohesion.*

Study context

The parent trial was conducted in Dar es Salaam, Tanzania. Tanzania is an east African country with a population of 45 million (2015 census) [19]. It is a low-income country with an estimated annual \$2,700 gross domestic product per capita (2014 estimate) and a growing economy (2014 growth rate estimated at 7%) [20]. Tanzania's population has a median age of 18 with a life expectancy of 61 years at birth [21]. Dar es Salaam is the nation's largest city and commercial capital, with a population 4.4 million comprising approximately 10% of the nation's population [19]. Located on the country's eastern coast on the Indian Ocean, it lost its position as the nation's capital to the more centrally located Dodoma in 1974 but remains the focus of much of the permanent central government bureaucracy. An estimated 70% of the city's population lives in informal settlements [22].

HIV/AIDS in Tanzania. Over 1,400,000 people in Tanzania are living with HIV. HIV/AIDS remains the leading cause of death in Tanzania [21], with approximately 80,000 AIDS-related deaths annually [23]. 80% of new HIV infections in Tanzania are estimated to be attributable to heterosexual transmission [23]. 5% of Tanzanian adults ages 15-49 are HIV-positive (6% of women and 4% of men) [1]. The proportion of people living with HIV (PLHIV) rises in successively higher age cohorts; the prevalence among those ages 20-24 is 3% (4% among women and 2% among men), 5% among those 25-29 (7% among women, 3% among men), and 8% among those 30-34 (9% among women, 7% among men) [1]. As in many settings, women are at greater risk of being HIV infected than men [1]. Other groups at heightened risk include men who have sex with men (22% prevalence), people who inject drugs (16% prevalence), and female sex workers (31% prevalence) [23]. Youth in Tanzania are at particular risk of HIV infection; 60% of new infections in Tanzania occur among 16-24 year olds [24], and an estimated 17% of females and 8% of males ages 15-19 are living with HIV in Tanzania [3]. The populations of the

country's urban areas also have a higher than average prevalence of HIV (7 % versus the national average of 5 %) [1]. The HIV prevalence in Dar es Salaam is estimated at 7% [1].

In 2010, 34% of health facilities in Tanzania offered HIV testing and counseling services and 13% offered antiretroviral therapy [1]. In 2013, 62% of women and 47% of men had ever been tested for HIV and received the results of their test [1]. Testing in ante- and perinatal care settings matches the rate among the general population of women (62%) [1]. Though nationally the majority of clients receiving testing services are women, in Dar es Salaam 76% of new clients are men [1]. Only 57 % of the country's estimated 1,400,000 PLHIV are enrolled in HIV care [1].

Mental health in Tanzania. Very little is known about the mental health of Tanzania's population. There are no estimates of the prevalence of common mental disorders including anxiety and depression to my knowledge. In one study of primary care attendees, the prevalence of depression and "mixed anxiety-depressive disorder" were 15% and 7%, respectively [25]. In another study of HIV-positive patients in rural Tanzania, 16% of patients presented symptoms of depression or mixed anxiety and depression, and 5% suffered from other anxiety disorders [26]. Further, there are very few treatment services available for people suffering from anxiety, depression, and other common mental disorders in Tanzania; per 100,000 population there are only 2 psychiatric nurses, 0.04 psychiatrists, and 0.005 practicing clinical psychologists [27].

Overview of the parent trial

The dissertation research was conducted within the chair's NIMH R01, *A Multilevel Intervention to Reduce HIV Risk Among Networks of Men in Tanzania* (PI: Suzanne Maman; 1R01MH098690-01), a cluster randomized trial aiming to determine whether men in social groups known as "camps" randomized to receive a microfinance and health leadership intervention have a lower incidence of

sexually transmitted infections and report perpetrating less physical and sexual violence against female sexual partners as compared to men belonging to camps randomized to a control condition.

Dr. Maman and the research team of the parent study identified social networks of young men occupying designated venues known as “camps” in Dar es Salaam where men socialize and engage in small scale enterprise [28]. Participants in the parent study were male members of 59 of these camps. Camps are stable social units; those included in the trial had been in existence for an average of eight years. Men typically belong to only one camp and pay membership fees to belong to that camp [28]. Camps are made up of entrepreneurial youth who frequent the venue for its supportive social environment [28]. Most men in the camps are not formally employed and spend several hours each day at their camp [28].

These camps provided unique access to social networks of high risk young men who are otherwise difficult to reach, as they are largely neither in school nor formally employed [28]. Complete longitudinal, sociocentric network data from 59 camps of 1249 young men were available from the parent trial, providing a unique opportunity to examine social network influences on young men’s sexual risk. Men in these camps show increasing sexual risk behaviors over the teen years [29], and report high levels of anxiety and depression (19% and 21%, respectively based on common clinical cutoffs) [30].

Overview of analyses

The Aims were completed using multilevel modeling and social network analysis. In the analysis for all Aims, individual- and camp-level sources of variation in sexual risk behaviors were accounted for using multilevel models. In Aim 1 I assessed the longitudinal relationship between mental health and sexual risk. Evaluation of Aim 2 hypotheses was completed using quadratic assignment procedures to test the correlations between peers’ reported sexual behaviors (hypothesis 2a), and extensions of the multilevel models from Aim 1 to test peer norms as moderators of the relationship between mental health and

sexual risk (hypothesis 2b). Finally, for Aim 3, I again expanded the models from Aim 1 to test the interactions between mental health variables and each hypothesized moderator of network cohesion and centrality. For all significant interactions found, I probed and interpreted the nature of the interaction.

1.4 Significance of the dissertation study

The dissertation research provides novel evidence of the potential causal relationship between mental health and sexual risk in a population of young men living in Dar es Salaam, and the extent to which this relationship is socially influenced. The sociocentric network data from 59 camps available from the parent trial presented the rare opportunity to explore the influence of social network peers on the relationship between mental health and sexual risk. The results of this research provide implications for the combination of sexual risk reduction and mental health promotion interventions in this population, as indicated in other settings [31]. The findings further provide evidence essential to the future development of interventions to reduce HIV risk among marginalized populations of young men, by providing understanding of potential ways to leverage the influence of social networks to address mental health as a risk factor for HIV transmission.

1.5 Organization of the dissertation

This dissertation has seven chapters. This first chapter serves as an introduction to the dissertation and provides an overview of the problem motivating the dissertation research, the purpose and significance of the study, the research approach, and a description of the study context. Chapter 2 provides the rationale for the dissertation Aims based upon theory and empirical evidence; Aims 1, 2, and 3 are presented with corresponding hypotheses. Chapter 3 includes a detailed description of the research

design and methods used in the study. Chapter 4 presents the results for Aim 1 on the association between mental health and sexual risk behaviors in manuscript form. Chapter 5 includes the results of Aim 2 on the moderating role of peer norms in the relationship between mental health and sexual risk, also in manuscript form. The results of Aim 3 on the moderating role of network cohesion and centrality in the relationship between mental health and sexual risk are presented in Chapter 6; these results were excluded from the second manuscript (Chapter 5) and are not intended for further publication. A discussion of the results across the three Aims is presented in Chapter 7, as well as a summary of the study strengths, limitations, and implications for future research and interventions.

CHAPTER 2: RATIONALE AND EMPIRICAL AND THEORETICAL SUPPORT FOR AIMS

2.1 Aim 1 rationale

Aim 1
Evaluate the longitudinal relationship between mental health (anxiety, depression) and sexual risk behaviors (condom use, concurrency) among young men.

Youth in Tanzania are at high risk for HIV infection [1], and young men are important targets in preventing HIV transmission as gender norms position them to control the terms and conditions of sexual relationships [32], and encourage them to engage in high risk sexual behaviors such as inconsistent condom use and sexual partner concurrency [1, 33-36]. To date, few studies have attempted to understand the unique predictors of risky sexual behaviors among young men in low resource settings such as Tanzania [37, 38]. A better understanding of predictors of sexual risk in young men in this context is needed to inform effective HIV prevention strategies.

Key predictors of HIV infection in sub-Saharan Africa include, but are not limited to, condom use and sexual partner concurrency [39]. Condom use has been shown to be effective in preventing the transmission of HIV for both men and women; lower levels of condom use for penetrative sex acts are associated with increased risk of HIV transmission [40]. Concurrent sexual partnerships (multiple coinciding sexual relationships) also present an important risk factor in the transmission of HIV and other STIs [41-43], by decreasing the time from an exposure to the next sexual contact, and increasing the likelihood of exposure to acute infection when HIV is the most transmissible [44-46]. These risk behaviors are of particular relevance for young men in Tanzania as the majority of the young men in Dar

es Salaam report condom use at last sex, but this proportion declines from 92% among 15-year-olds to 70% among 19-year-olds [29], indicating a decreasing motivation for condom use over adolescence. Among the same population, the proportion reporting concurrent sexual partnerships increases with age, with 5% reporting concurrency at age 15, to 44% reporting concurrency by age 19 [29]. The low levels of condom use and high rates of concurrency found among men in Dar es Salaam are consistent with national studies in Tanzania; half of sexually active youth ages 15-24 surveyed in Tanzania in 2010 did not use a condom at last intercourse [4]. Further, nearly one third of young men in Tanzania reported concurrent partners in 2010 [4], making sexual concurrency an important target risk behavior in this population.

Anxiety and depression as predictors of sexual risk have been studied in high-income settings, primarily in adult populations. Mental health may influence sexual risk through multiple mechanisms including substance use [10], maladaptive coping mechanisms to deal with stress [47], and impaired decision making [48]. Primarily cross-sectional associations have been found between both anxiety and depression, and sexual risk behaviors (condom use and concurrency) [5-10], with a few previous studies having observed a predictive association between mental health and sexual risk in longitudinal studies [8, 9, 11, 12, 49].

A review of the literature on the relationship between mental health and sexual risk behaviors primarily yielded evidence from high income settings. To ensure an exhaustive understanding of studies from sub-Saharan Africa, I conducted a systematic review of the literature on the relationship between mental health (anxiety and depression) and sexual risk (condom use concurrency). To be included in the review studies had to have any measure of condom use, and/or any measure equivalent to sexual partner concurrency. For the purposes of the dissertation research, studies among HIV-positive only populations were excluded. The search yielded a total of 138 articles, with a final yield of 9 eligible

articles. A description of each article is presented in Table 1 and the results of these studies are presented in Table 2. Systematic review results

The majority of the studies included in the review either sampled exclusively undergraduate college students or were conducted among household-based samples of a given geographic area; there were few studies of high risk populations, with one study among female clients of drinking venues [50], and one study among men who have sex with men [51]. The latter study was the only one to focus exclusively on men. Moreover, all studies were cross-sectional, precluding the ability to draw temporal conclusions about any relationships seen. Given that young men in this context are at heightened risk of HIV infection [1], and the majority of cases of anxiety and depression begin by age 24 [52], it is particularly important to understand if there is indeed evidence in this population of increased HIV risk behaviors in relation to levels of anxiety and depression.

Only one study included anxiety as a predictor of sexual risk. Further, there were far fewer studies of concurrency than condom use; several studies which were excluded looked at number of sexual partners within a given time period, but very few looked at concurrency specifically. In general, there was poor evidence of the relationship between depression and condom use or concurrency. The one study that tested the relationship between anxiety and condom use found a significant association among male undergraduates [7]. Two population-based studies found a significant association between depression and sexual risk behavior, one association with condom use [53], and one association with concurrency [9].

Altogether, the studies provided mixed support for the relationship between mental health and sexual risk behaviors. There may have been methodologic reasons for which these relationships were not observed, contributing to the risk of type II error (failure to reject a false null hypothesis). In general, studies suffered from over-adjustment for covariates, and often included covariates with high likelihood of collinearity with anxiety or depression, such as posttraumatic stress disorder (PTSD) symptoms.

Further, some studies had relatively small sample sizes and thus may have not been powered to detect significant relationships between mental health predictors and sexual risk behaviors. Lastly, most studies of condom use utilized a dichotomous measure of consistent condom use, i.e. participants were classified as either always using condoms or not. This treatment of condom use fails to capture important differences in condom use, specifically whether or not a person uses condoms ever. The dissertation study contributes to this literature by capturing qualitatively important levels of condom use while minimizing over-sensitivity to biases in participant recall through the use of a three-level variable.

This review made it clear that more studies from sub-Saharan Africa evaluating the link between mental health and sexual risk behaviors were needed, with a particular need for greater evidence of the potential link between anxiety and sexual risk, and of the risk of sexual partner concurrency in relation to mental health. The dissertation research addresses these gaps in the literature. It further provides novel evidence in this setting of these relationships in a population primarily composed of men who have sex with women. Despite poor evidence among review articles supporting the relationships between depression, anxiety, and sexual risk behaviors among populations in sub-Saharan Africa to date, support for these relationships from high income settings indicated that the relationship in this setting may have been under-explored and merited further investigation. Specifically, I hypothesized:

Hypothesis 1: *Young men experiencing increased symptoms of anxiety and depression from time 1 to time 2 will report less frequent condom use and be more likely to report engaging in sexual partner concurrency at time 2, controlling for time 1 behaviors, than young men experiencing decreased symptoms of anxiety and depression.*

The results of this aim provide much needed longitudinal evidence of the nature of the relationship between mental health and sexual risk in the sub-Saharan context. This contribution to the understanding of a potential causal relationship between mental health and sexual risk behaviors has implications for the importance of integrating mental health promotion and HIV prevention interventions targeting the growing population of male youth in sub-Saharan urban areas.

Table 1. Systematic review articles

Authors and year	Title	Location	Population	Study design	Sample size by sex
Agardgh et al. 2012 [7]	<i>Youth, Sexual Risk-Taking Behavior, and Mental Health: a Study of University Students in Uganda</i>	Mbarara, Uganda	Undergraduate university students	Cross-sectional	633 men; 329 women
Asante & Andoh-Arthur 2014 [54]	<i>Prevalence and determinants of depressive symptoms among university students in Ghana</i>	Accra, Ghana	Undergraduate university students	Cross-sectional	132 men; 138 women
Gupta et al. 2010 [55]	<i>Depression and HIV in Botswana: A Population-Based Study on Gender-Specific Socioeconomic and Behavioral Correlates</i>	5 Districts in Botswana	Household-based probability sample of 18–49 year-olds	Cross-sectional	580 men; 597 women
Lundberg et al. 2011 [9]	<i>Poor mental health and sexual risk behaviours in Uganda: A cross-sectional population-based study</i>	Kampala and Mbarara, Uganda	Household-based probability sample	Cross-sectional	334 men; 312 women
Otieno et al. 2015 [56]	<i>Risky HIV sexual behaviour and depression among University of Nairobi students</i>	Nairobi, Kenya	Undergraduate university students	Cross-sectional	525 men; 365 women
Peltzer et al. 2013 [57]	<i>Mental health, childhood abuse and HIV sexual risk behaviour among university students in Ivory Coast</i>	Cocody, Ivory Coast	Undergraduate university students	Cross-sectional	412 men; 412 women
Pitpitan et al. 2012 [50]	<i>Co-occurring Psychosocial Problems and HIV Risk Among Women Attending Drinking Venues in a South African Township: A Syndemic Approach</i>	Capetown area township, South Africa	Female clients of drinking venues	Cross-sectional	560 women
Smit et al. 2006 [53]	<i>Mental health and sexual risk behaviours in a South African township: A community-based cross-sectional study</i>	Capetown area township, South Africa	Population-based sample: Participants in larger HIV risk study	Cross-sectional	252 men; 357 women
Stahlman et al. 2015 [51]	<i>Depression and Social Stigma Among MSM in Lesotho: Implications for HIV and Sexually Transmitted Infection Prevention</i>	Maseru and Maputsoe, Lesotho	Men who have sex with men recruited	Cross-sectional	530 men

Table 2. Systematic review results

Authors/ year	Mental Health Constructs	Mental Health Measures	Sexual Risk Measures	Results: Men and women	Results: Men only	Results: Women only
Agardgh et al. 2011	Anxiety, Depression	HSCL-25 (median score as cutoff)	Inconsistent condom use (at last sex)	--	Anxiety but not depression significantly associated with inconsistent condom use Anxiety AOR: 1.9 (1.1–3.6) Depression AOR: 1.6 (0.9-3.0)	No significant association Anxiety AOR: 2.1 (0.9–4.7) Depression AOR: 1.1 (0.5-2.5)
Asante & Andoh-Arthur 2014	Depression	CES-D 10 (cutoff ≥ 10)	- Concurrency (multiple sexual partners) - Inconsistent condom use	No significant associations Concurrency AOR 0.67(0.32–1.42) Condom use AOR: 0.74(0.36–1.53)	--	--
Gupta et al. 2010	Depression	HSCL-25 depression subscale (cutoff ≥ 1.75 mean score)	Inconsistent condom use (past 12 months)	--	No significant association AOR: 1.23 (0.78–1.95)	No significant association AOR: 0.82 (0.52–1.31)
Lundberg et al. 2011	Depression	HSCL-25, depression sub-scale (cutoff ≥ 16)	- Concurrency (0-1 vs. 2 or more current sexual partners) - Consistent condom use (always vs. sometimes/ never)	--	No significant association Concurrency AOR: 1.52 (0.60-3.86) Condom use AOR: 2.71 (0.72-10.20)	Depression significantly associated with concurrency Concurrency AOR: 3.92 (1.25-12.27) Condom use AOR: 2.12 (0.79-5.68)
Otieno et al. 2015	Depression	CES-D 10 (10–14 moderate; ≥15 severe)	Inconsistent condom use (past 3 months with primary partner)	No significant association Moderate depression AOR: 0.92 (0.61–1.39) Severe depression AOR: 1.18 (0.47–2.97)	--	--
Peltzer et al. 2013	Depression	CES-D 10 (cut-off ≥10)	Inconsistent condom (past 3 months)	--	No significant association	No significant association

Authors/ year	Mental Health Constructs	Mental Health Measures	Sexual Risk Measures	Results: Men and women	Results: Men only	Results: Women only
					Condom use OR = 0.69 (0.35–1.36)	Condom use OR: 1.04 (0.54–2.01)
Pitpitan et al. 2012	Depression	CES-D (cutoff ≥ 16)	% unprotected sex acts (past 4 months)	--	--	No significant association AOR = 1.30 (0.67, 2.50)
Smit et al. 2006	Depression	CES-D (cutoff ≥ 20)	No condom use (past 6 months)	Depression associated with higher levels of condom use AOR: 5.32 (2.74-10.29); p<.001	--	--
Stahlman et al. 2015	Depression	Patient Health Questionnaire (cutoff ≥ 10)	Unprotected sex (past 30 days)	--	No significant association AOR = 0.72 (0.38-1.39)	--

2.2 Aim 2 rationale

Aim 2
Assess the level of social influence on young men's sexual risk behaviors, and the moderating role of social norms in the relationship between mental health and sexual risk behaviors within camp networks.

Empirical evidence

Previous studies have shown that peers' mental health status affects an individual's own mental health [16, 17] and sexual risk behaviors [18], but we have little understanding of the potential influence of peers in patterns of mental health and sexual risk within the same network. Understanding such an influence on the relationship between mental health and sexual risk in young men's social networks would allow us to discern if there is something social or learned about sexual risk as a response to poor mental health. Experts have called for combined sexual risk reduction and mental health promotion interventions [31], and the results of the dissertation research provide essential evidence to determine the appropriateness of such interventions in this setting.

Past studies indicate that individuals' sexual behaviors, including partner concurrency [58] and condom use [59-62], reflect their peers' behavior. Specifically, these studies found that youth who perceived higher levels of concurrency or lower levels of condom use among their peers were more likely to display concurrency or lower levels of condom use themselves. Peer influence and similarity in sexual behavior has been less frequently studied from a social network perspective than mental health, indicating a need for further research in this area. Though the influence of mental health and peer norms have been studied separately as predictors of sexual risk, to my knowledge there were no studies prior to the dissertation study assessing the interaction between individual-level mental health and peer norms in predicting sexual risk behaviors.

Theoretical rationale

Berkman's model. Development of hypotheses pertaining to social network influence on the relationship between mental health and sexual risk was guided by Berkman's model of social network influence on health behaviors [63]. This model offers a multilevel framework for understanding the influence of social network structure and ties on individual behaviors. Berkman posits that both the structure of a social network and qualities of the ties between individuals within the network shape interpersonal social processes including social support, social influence, social engagement and role formation, and access to goods and resources; in turn, these social processes influence individual behaviors [63]. I used this model to guide my thinking and review of the literature on the potential role of social networks in shaping young men's sexual risk behaviors in interaction with their mental health. Social influence emerged as the most salient psychosocial mechanism through which the form and function of social networks might shape the behaviors in question.

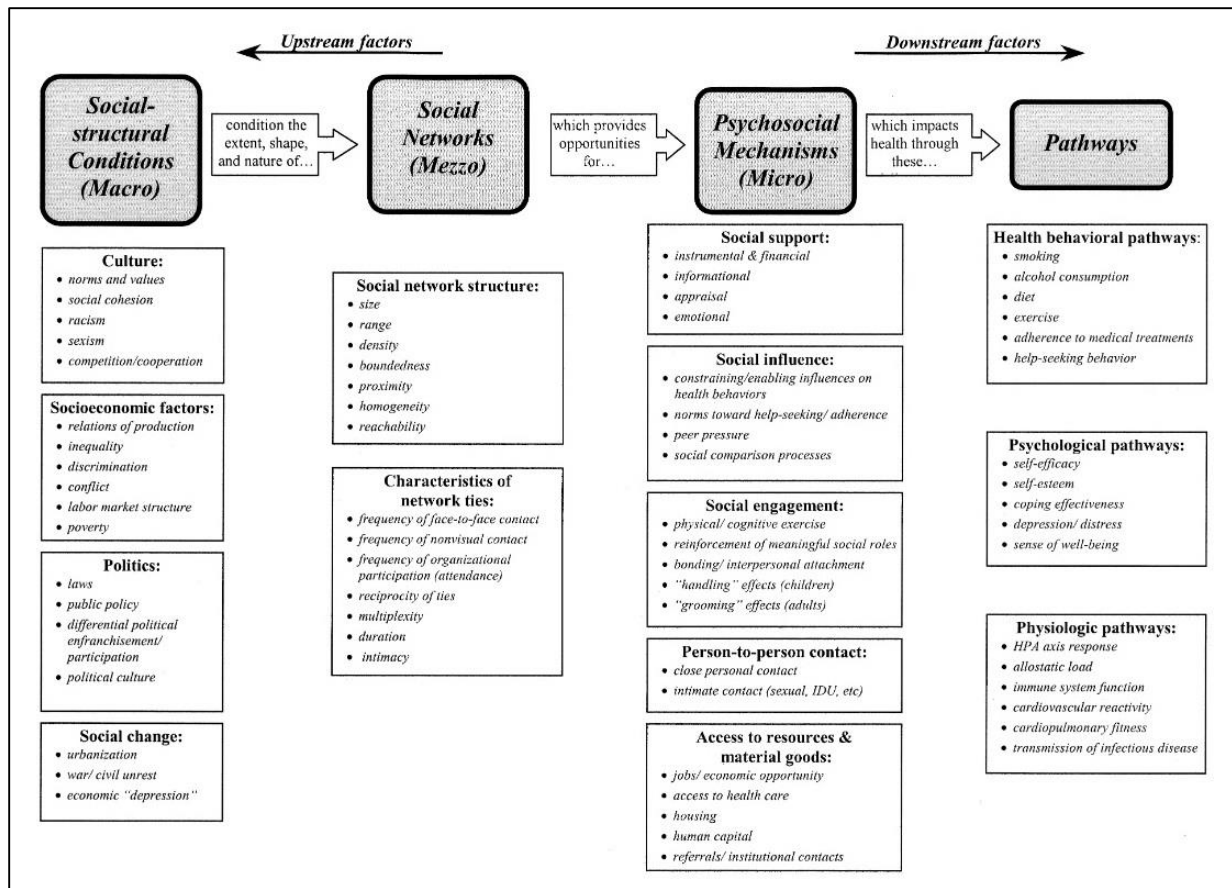


Figure 2. Berkman et al., 2000

Social influence

Focusing on the mechanism of social influence from Berkman's model, the hypotheses related to peer influence on individual sexual risk behaviors, and the relationship between mental health and sexual risk were guided by additional theories specific to social influence. Social networks shape social influence by providing structural opportunities for interactions between network members [64, 65]. Network peers who are structurally proximal, or who have direct connections, have the ability to directly influence one another. In this way peers develop shared attitudes, perceptions, and behaviors with structurally proximal peers in social networks [65]. Network members not only have the ability to influence one another through direct contact, but can also indirectly influence peers to whom they are not directly tied [66]. An individual may watch and model a friend's behavior, such as partner concurrency, and may

in turn influence other friends, thereby mobilizing a process of behavioral contagion throughout a whole network [67].

In this Aim, I focused on direct interactions as the basis of peer influence. I hypothesized that network members who have strong relationships (i.e. friendships) interact frequently and by consequence develop similar behaviors. Young men's interactions with friends in their network will create opportunities to directly observe and model how their friends think, feel, and behave. Following Marsden and Friedkin's hypothesis that the more proximal two individuals are in a network, the more influence these actors will have on one another [34], I hypothesized:

Hypothesis 2a: *Young men's sexual risk behaviors will be more correlated with those of friends than with those of other members of their camp network.*

I further explored the interaction between individual mental health and peer risk behavior norms in shaping young men's sexual risk behaviors. Peer influence not only acts independently to shape behavior but peers also serve as a reference groups which individuals look to in behavioral decision-making [68]. In Aim 1, I hypothesized that increases in symptoms of anxiety or depression would increase the likelihood of engagement in sexual risk behaviors. In Aim 2, I further hypothesized that more normative risk behaviors among direct peers will serve to magnify this individual-level risk. In other words, men who experience increased levels of anxiety or depression may have a higher inclination toward risk behaviors, and the influence of riskier norms among their friends may increase the likelihood that this inclination manifests in actual risk behaviors. Specifically, I tested the following hypothesis:

Hypothesis 2b: *The relationship between mental health and sexual risk will be moderated by peer sexual risk behavior norms such that the relationship will be stronger for young men exposed to riskier peer norms than for men exposed to less risky peer norms.*

2.3 Aim 3 rationale

Aim 3
<i>Test social network characteristics (centrality, social cohesion) as moderators of the relationship between mental health and sexual risk behaviors.</i>

Defining constructs

Centrality is a measure of an individual's position within a given social network; measures of centrality capture the closeness of an individual to their peers in a network [69, 70]. There are many operationalizations of centrality; the one used in this study is *in-degree centrality*, or the number of friendship nominations that an individual receives from other members of his network [69]. Borgatti describes degree centrality as relating to an individual's ability to contribute to the spread of information in a network [69]. He also describes degree centrality as reflecting the volume of ties an individual has rather than the relative distance (in terms of ties), or closeness, to other members in the network [69]. For the purposes of this Aim I selected in-degree centrality as measure to capture the extent to which men are to be supported and influenced by their closest peers. This type of centrality can be thought of as a measure of popularity, as the more peers who nominate that individual as a friend, the more prominent or popular they can be thought of as being in their network [71].

Social cohesion has a wide range of definitions across disciplines, but roughly relates to the connectedness and togetherness of a defined social group, either perceived or observed [72]. Among the earliest to discuss this construct, Durkheim observed the relationship between social integration and suicide rates, finding higher levels of suicide in less integrated societies [73]. In contemporary research, many choose to place an emphasis on the importance of perceived social cohesion, as seen in the research of Bollen and Hoyle who proposed that individuals' perceptions of their group's cohesion influences both the individual and the group sense of belonging and morale [74]. In contrast, other researchers have focused on structural rather than perceived measures of cohesion including Moody

and White [75]. Moody and White's measure of *structural cohesion* captures a dimension of *relational cohesion* in a network defined as the "extent that the social relations of [a network's] members hold it together" [75]. Operationally, this concept translates to the extent to which the connectedness of a network depends on a few or many actors in that network, or the number of independent paths between any two given individuals in a network [75]. In other words, a network is more cohesive if the relational togetherness of the group does not depend on only a few people, and this dependence is decreased by greater connections between individuals in the network. Taking the example of a group of friends, if one person is the primary "hub" (strongly tied to all/most others) and everyone else in the group is primarily friends with the hub and only friends by association with everyone else, that group is not very cohesive given that their cohesion as a group is dependent upon a single person. On the other hand, if there are many independent strong friendships within a friend group, if one person leaves the group is not likely to fall apart, for there are many ties that bind the group together. To understand the influence of both structural and perceived cohesion, I assessed the moderating role of both men's reports of cohesion in their network, and structural cohesion measured as discussed by Moody and White using sociocentric data from each camp network.

Theoretical rationale

Hypotheses related to social network moderators of the relationship between mental health and sexual risk were again guided by Berkman's model, specifically by the indication of this model that social network structure shapes social support via increased opportunities for social interaction. Macro-level network structure and an individual's connections within the network will shape exposure to micro-level mechanisms, including social support [76]. Specifically, I posited that greater social cohesion increases opportunities for social support. Centrality reflects an individual's connectedness to other members in the network, and greater centrality increases the individual's ability to receive social support from

others in the network [77]. As with cohesion, I hypothesized that the higher an individual's centrality within the network, the more opportunities they have for social support. Both cohesion (at the group level) and centrality (at the individual level) shape opportunities to interact with peers, who can provide social support in the face of emotional distress.

The ability of social support to reduce the likelihood of risk behaviors is supported by Cohen's stress buffering theory, which indicates that social support can operate to intervene between the experience of stress (in this case, the experience of anxiety and/or depression) and maladaptive coping behaviors (such as sexual risk behaviors) by reducing the effect of the stressor or by affecting the psychological processes which occur in response to the stressor [78]. Lazarus and Folkman's Transactional Model of Stress and Coping provides further support for social support's role in promoting positive rather than negative coping outcomes [79], again indicating network social support as a potential moderator between stress related to anxiety and depression and maladaptive coping outcomes (sexual risk behaviors). Lazarus and Folkman posited that social support buffers the relationship between stressors and health behaviors by acting upon coping efforts (actions and processes to deal with the effect of stress), including problem management and emotional regulation (see Figure 3. Transactional model of stress and coping below) [79].

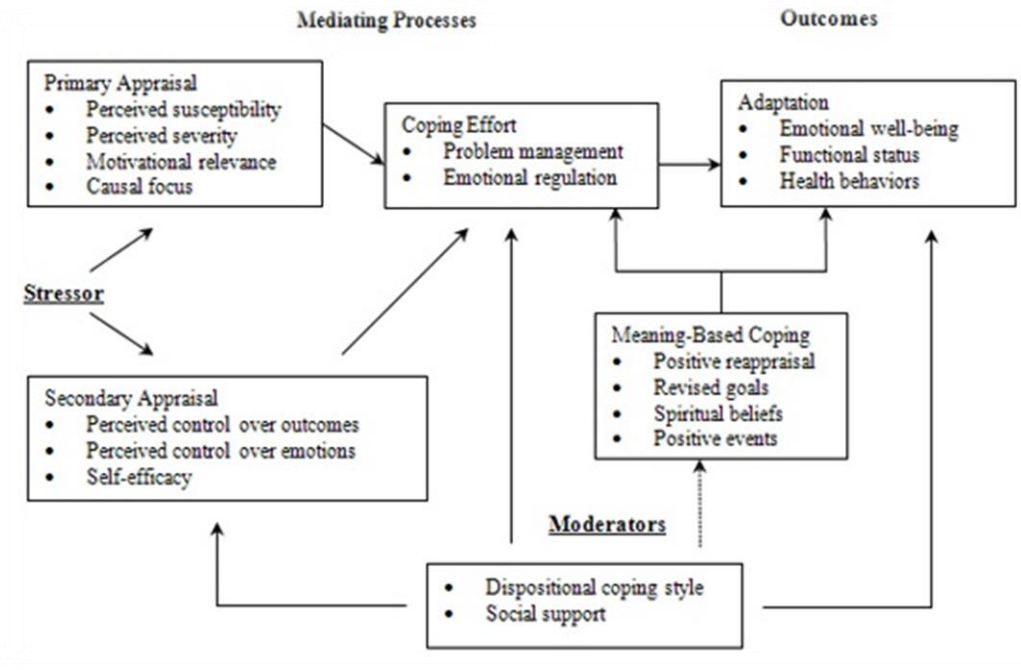


Figure 3. Transactional model of stress and coping

Rather than testing the role of social support as buffer of the relationship between mental health and sexual risk directly, I aimed instead to test the buffering effect of network position (centrality) and connectivity (cohesion) on this relationship as measures of the structural opportunity for social support. While there is much interest and previous research on the health promoting effects of social support, a functional aspect of social relationships, little attention has been paid to the health impact of the structure of social relations. While I highlight social support as an explanatory mechanism through which social structure functions to affect health, I was primarily interested in network structure as a novel point of investigation and potential future public health intervention. Guided by the above theoretical logic, I hypothesized that higher levels of social network cohesion and centrality would buffer the association between mental health and sexual risk. Specifically, I hypothesized:

Hypothesis 3a: *Young men's centrality within their camp social network will moderate the relationship between mental health and sexual risk behaviors such that the relationship will be weaker for men with higher centrality than for those with lower centrality.*

Hypothesis 3b: *Network social cohesion will moderate the relationship between mental health and sexual risk behaviors such that the relationship will be weaker for young men in camps with higher levels of social cohesion than for those in camps with lower levels of social cohesion.*

Empirical evidence

Prior to the dissertation research, there were no studies to my knowledge evaluating these hypothesized relationships, nor the direct relationship between network centrality or cohesion and sexual risk behaviors. There is evidence in the literature, though limited, that network centrality predicts receipt of social support [80], which in turn is related to sexual risk behaviors [81, 82]. This evidence further supports social support as the mechanism through which network cohesion and centrality may work to buffer the relationship between mental health and sexual risk behaviors. It also further indicates a need to better understand the effects of network structure and position on this and other stress and coping relationships.

CHAPTER 3: STUDY DESIGN AND METHODS

3.1 Research strategy overview

The dissertation research was completed using two waves of data from the chair's NIMH R01, *A Multilevel Intervention to Reduce HIV Risk Among Networks of Men in Tanzania* (PI: Suzanne Maman; 1R01MH098690-01). All data were taken from the behavioral and social network questionnaires from this trial. The analyses for all three aims were conducted in SAS v 9.4 using multilevel modeling and quadratic assignment procedures. Social network measures used in Aim 3 were calculated using UCINET 6.

3.2 Parent trial context and procedures

Parent trial aims

The parent trial is a cluster randomized controlled trial assessing the efficacy of a combined microcredit and health leadership intervention to reduce HIV risk and intimate partner violence. The first aim of the parent study is to enumerate and characterize camps in four wards of Dar es Salaam where young men at high risk for HIV acquisition and transmission socialize, in order to generate a pool of camps for inclusion in the larger trial. The second aim is to conduct a cluster randomized trial to determine whether men in camps randomized to receive a microfinance and health leadership intervention have a lower incidence of sexually transmitted infections and report perpetrating less physical and sexual violence against female sexual partners as compared to men belonging to camps that are randomized to a control condition.

Recruitment and sampling

The parent study team identified camps for inclusion using an adaptation of PLACE (Priorities for Local AIDS Control Efforts) methodology, a rapid assessment designed to locate venues where people meet new sexual partners through community informant and camp verification interviews. Approximately two community informants per 1,000 people in each of the four participating study wards were recruited for interviews, or 489 individuals completing a total of 619 verification interviews. A list of potential camps in the four study wards, and directions to these camps were documented through these interviews. A total of 303 camps were verified and all camps were mapped with GIS software. To be eligible for inclusion in the trial, camps had to have between 20 and 80 members, have been in existence for at least one year prior to the baseline assessment, and report no violent incidents with weapons in the past 6 months. A total of 303 camps were verified, of which 205 were eligible. Of the 303 verified camps, 98 camps did not meet the parent study's inclusion criteria (6 camps had previously been included in a pilot study and were ineligible for this reason, 51 camps had fewer than 20 members, 16 camps had more than 80 members, 4 camps had not been existence for at least 1 year, 23 camps reported that a weapon had been used in a fight in the last year, and 9 camps were removed because the research assistants felt unsafe during the preliminary data collection).

GIS was used to map the coordinates of each camp and to group geographically contiguous camps into 93 clusters prior to random selection of 60 study camps. In the event that multiple camps from the same cluster were selected for inclusion in the trial, these camps were assigned to the same condition to minimize contamination. All camps identified through community informant interviews were visited for camp verification interviews to confirm camp existence and current operation, record GPS coordinates, and record characteristics of the camp through interviews with camp leaders. Camps included in the sampling frame were those confirmed to exist and be in operation, for which GPS coordinates were recorded, and for which at least half of the camp verification interview questions were

completed. Of the 205 eligible camps identified, 60 camps were randomly selected for inclusion in the study. One camp was later excluded from the trial during midpoint data collection when its members reported to the study team that they were not a legitimate camp. Data from the remaining 59 camps were used in this dissertation.

All members of camps selected into the trial were preliminarily eligible for inclusion in the study. Following random selection, camp leaders were given a camp roster template to complete. The camp leaders were responsible for recording the name of every camp member as well as their birthdate, gender, phone numbers, length of time as camp member, whether or not the member intended to stay in the city for the next 30 months, and whether or not members were willing to give contact information for two friends or family members. To be eligible for the parent study at baseline, participants had to: 1) be a registered camp member for at least three months; 2) plan on residing in Dar es Salaam for the next 30 months; 3) be 15 years or older; 4) visit the camp at least once per week; and 5) be willing to provide contact information for themselves and two family members or friends. Those members listed on the roster as being younger than 15 or having not been a member for at least three months were deemed ineligible. All other members were deemed preliminarily eligible and were contacted for an interview to further assess their eligibility. Participants who were unwilling to provide locator information or were unable to participate due to psychological disturbance, cognitive impairment, or threatening behavior were excluded from the quantitative assessment. All eligible members were offered participation in the trial and asked to complete the baseline survey.

Of 1,948 camp members approached for participation, 1,500 completed the baseline survey. This level of non-response is primarily accounted for by various sources of ineligibility and inability to participate in the parent study. 284 camp members could not be reached for enrollment either because the study team was unable to contact them (101, 5.2%), or because the study team was unable to schedule an appointment with them (183, 9.4%). A further 112 (5.8%) individuals did not meet the

study's eligibility criteria, and an additional 49 (2.5%) refused to participate. Soon after baseline data collection, camp members from one camp (n=9) requested to be removed from the study because they were not a real camp and came together only for the purpose of being in the trial. This camp was removed from the study, resulting in a final sample of 1,491 individuals within 59 camps. The final response rate among potentially eligible participants (n=1,948) was 76.5% after the removal of this camp. The camps enrolled in the parent trial had an average of 33 members, ranging in size from 20 members to 77 members (SD = 12). The mean number of baseline survey participants per camp was 25 (range 7-66), for an average camp-level response rate of 78% (range 36-100%).

Written informed consent was required for participation in the community informant and camp verification interviews. Potential interviewees were read a script outlining the purpose of the interviews and given the opportunity to ask questions or clarifications. Participants consented to the interview by signing and writing the date on the form. Potential participants were excluded from participation if they were unable to provide informed consent. At the baseline behavioral assessment participants were asked to provide written consent to participate in the trial. Participants were informed that they would be re-contacted to participate in follow-up behavioral assessments. Upon providing written consent to participate in the study, the participant provided contact information. In all study data, reports, and study data collection, process, and administrative forms participants were identified by a coded number only to maintain confidentiality. All study data were stored separately from study records that contained participant names or other personal identifiers.

Data collection

After random selection and informed consent, 1249 male participants and 242 female participants completed the baseline assessment starting in Fall 2013, and a follow up assessment 12 months after the launch of the intervention. The baseline survey was administered by trained Tanzanian interviewers

in Swahili using computer assisted personal interviewing (CAPI) from October 2013 through March 2014. The follow-up survey was administered using the same methods from March 2015 through September 2015. The behavioral assessment included questions about the following topics: demographics, hope, future orientation, camp social cohesion, camp collective efficacy, anxiety symptoms, depression symptoms, gender equity, conflict tactics, HIV stigma, alcohol and drug use, sexual relationships and risk behaviors, attitudes towards HIV risk behaviors, sexual networks, social networks, work, and expenditures. Participants also completed a social network questionnaire in which they were offered a list of all of the members of their camp and asked to: a) state whether they knew each person; and b) characterize their relationship with each known person as an acquaintance, a friend, or someone they didn't get along with. The programming of the baseline assessment on tablet devices streamlined all skip patterns, and interviewers were intensively trained using both paper and electronic versions of the assessment tools to ensure their understanding of the logic built into the questionnaire. The interviews lasted approximately 60-90 minutes.

All data collected were subject to strict quality assurance measures at several levels. At the field level, team leaders in each field office had the ability to review data on the tablets for completeness before transmitting the data for processing by the central data manager, based in Delhi, India. Additional quality control measures were in place as the data was processed. I conducted my statistical analyses using a dataset with no individually identifying information.

Sample description

1249 men were interviewed at baseline, of whom 1113 reported being sexually active. All analyses were carried out among these 1113 sexually active men. Sexually active men interviewed at baseline had an average age of 27 years (range: 15 to 59). Over half had a primary school education or less (59%), nearly

a third had graduated from secondary school (31%), and the remaining 11% had some secondary school but had not graduated. A quarter of the men had ever been married (25%) and 38% had children.

Table 3. Baseline Participant Characteristics (n=1113)^a

	Total
Age (y) ^{***}	26.8 ± 7.1
Currently in school	97 (8.7%)
Education level (ref = less than primary school completed)	
Primary school or less	652 (58.7%)
Some secondary school	116 (10.5%)
Secondary school completed or greater	342 (30.8%)
Socioeconomic status	
Lowest	291 (26.2%)
Middle	435 (39.1%)
Highest	386 (34.7%)
Ever married	277 (25.0%)
Has children	423 (38.0%)

^aData are expressed as No.(%) or Mean ± SD

Ethical review

The parent study was approved by the ethical review committees at the University of North Carolina at Chapel Hill and Muhimbili University of Health and Allied Sciences in Dar es Salaam, Tanzania. Individual written informed consent was obtained from all study participants. Secondary data analysis of the parent trial data for the dissertation research was approved by the UNC IRB.

3.3 Measures

Dependent variables

Condom use was measured through self-report. For each of their three most recent sexual partners, men reported how many times they engaged in sex with these partners over the most recent month of

the relationship, and how many of these times they used a condom. I calculated men's proportion of condom use by dividing the number of times condoms were used by the total number of sex acts. Using these proportions, I coded observations into one of three categories: "never use" (0% use), "some use" (greater than 0%, less than 100%), or "always use" (100%). Because of the possibility of some degree of recall bias over the course of the three most recent relationships, use of a continuous variable of condom use is not indicated as each unit increase would not necessarily indicate an important difference in condom use. Dichotomizing condom use, however, is not recommended by Noar et al. [83], thus use of a three-level categorical condom use variable preserves information in differences in use while reducing the influence of recall bias.

Sexual concurrency was evaluated by self-report of any overlapping sexual partnerships for an individual's past 3 partners. Participants were asked to enumerate their three most recent sexual relationships and to report if they had sex with anyone else during any of these partnerships. Participants reporting any instance of simultaneous sexual relationships either currently or in the past 12 months were coded as reporting concurrency. This measure was developed following best practices recently recommended by USAID [84].

Individual-level independent variables

Symptoms of anxiety and depression were measured using the Hopkins Symptom Checklist-25 (HSCL-25) [85], specifically a version of the scale previously translated into Kiswahili and tested in Tanzania [86]. This measure inventories symptoms of anxiety and depression in 25 items (10 related to anxiety, 15 to depression) rated on a 4-point Likert-type scale. The scale has been previously validated in Tanzania [86, 87]. Anxiety scores were calculated by taking the mean of the 10 anxiety-related items in the HSCL-25. In the sample the anxiety subscale showed good internal consistency at baseline (Cronbach's alpha = 0.94). Depression scores were calculated by taking the mean of the 15 depression-

related items in the HSCL-25. At baseline the depression subscale also showed good internal consistency ($\alpha = 0.91$). Where depression and anxiety are described dichotomously, the recommended cutoff of 1.75 was used for clinical caseness [88]. This cutoff has been used in other studies using the HSCL-25 in sub-Saharan Africa [55, 89]. There is some indication that 1.67 may be a better cutoff for men [90], but I elected to use the more conservative cutoff of 1.75.

Individual-level covariates

Age Participants reported both their age in years and their date of birth. Participant age at baseline was calculated based on reported date of birth. This measure was used as the default value of the age variable with the exception of cases where the birthdate was not reported, in which case the reported age in years was used.

Education Participants reported the highest level of education they had completed by baseline based on 8 possible categories (no education, Standard 4 or less, Standard 5-7, Form 1, Form 2, Form 3, Form 4, Greater than Form 4). For analysis, education responses were collapsed into three categories: *Primary school or less* (responses: no education, Standard 4 or less, Standard 5-7); *Some secondary school* (responses: Form 1, Form 2, Form 3); or *Secondary school completed or greater* (responses: Form 4, Greater than Form 4).

Economic status was evaluated through an asset index, the Filmer Pritchett Wealth Index [91]. Participants were asked to indicate which of 10 possible assets they owned (e.g. cellphone, television) [92], and a composite score was created by weighting each asset by its factor loading on the first component in a principle components analysis and then placing individuals on a continuous scale of relative wealth [91]. The composite score for each participant was categorized into terciles based on the entire sample of men and women in our baseline dataset (the lowest 33% of participants were classified

as “lowest SES,” the highest 33% were classified as “highest SES,” and the remainder were classified as “middle SES”).

Marital status was evaluated through a single yes/no item in which men were asked if they had ever been married.

Camp-level covariates

Treatment condition. Each camp was randomized to either treatment or control condition in the parent trial. The treatment condition, which consisted of access to microfinance loans and peer health leadership training, was designed to affect condom use and sexual partner concurrency, thus it was included as important covariate to account for design effect.

Camp network moderators

Peer behavioral norm scores were calculated for each participant based on their friends’ reported behaviors as well as their own reported perceptions of their friends’ behaviors and views of condom use and concurrency. Four types of behavioral norms were measured for both condom use and concurrency: friend-reported behaviors (observed descriptive norms), perceived descriptive norms, perceived injunctive norms, and friend encouragement of the behavior. Men were asked to name their three closest friends in their camp by selecting names from a list of all camp members. The name of each friend was associated with a unique identifier which was used to link this nomination record to the friend’s reported behavior according to their own completed questionnaire. Taking the reported behavior of all three friends for each individual, I created an average percent condom use and a percent of friends reporting concurrency measure for each participant. To assess perceived descriptive norms, for condom use men were asked for each of these three closest friends, “*Do you think Friend X uses condoms all the time?*” For injunctive norms men were asked “*Do you think Friend X thinks that he*

should be using condoms all the time?" Finally, to assess friends' encouragement of behaviors men were asked *"Has Friend X encouraged you to use condoms all the time?"* Men were asked analogous questions for partner concurrency and provided yes/no answers. I created a measure of the proportion of friends for which the respondent answered "yes" for each item.

Structural social cohesion measures for each camp were calculated as described by Moody and White [75]. Each camp network received a social cohesion score. Structural social cohesion measures for each camp specifically captured the construct of structural cohesion, or the minimum number of nodes who, if removed, would disconnect the network, using methods describes by Moody and White [75]. Each network received a structural social cohesion score calculated as the average pairwise connectivity, or the mean of the total number of possible independent paths between all pairs of any two given individuals in the network [75]. I calculated these scores in UCINET 6 [93]. First, I created matrices of pairwise connectivity scores for each dyad by camp. I then converted these matrices to pairwise lists of connectivity values for each camp and used mean of these values as the structural cohesion value for each camp to test hypothesis 3b.

Perceived social cohesion was measured using an adapted scale for social cohesion developed by Sampson, Raudenbush, and Earls [94]. Participants responded to statements related to cohesion of camp members on a 4-point Likert-type scale ranging from 1 = strongly disagree to 4 = strongly agree. Statements included *"people in my camp are willing to help each other,"* and *"the members of my camp share the same values."*

Centrality can be thought of as the structural importance of a given individual within a network and can reflect the individual's ability to influence and be influenced by others in the network. Using a roster list including all members of each camp, men were asked to nominate their friends belonging to their camp by selecting their names from this list. Centrality measures, specifically in-degree centrality, were calculated as the proportion of people in the individual's camp network who nominated the individual as

a friend [95]. In-degree centrality was calculated within each network for each actor using UCINET 6 [93]. Standardized centrality scores were calculated as follows: **Centrality** = $\text{InTie}_{ij}/(n_j-1)$, where InTie_{ij} is the number of ties received by individual i within camp j , and n_j is the total number of actors in camp j .

3.4 Analytic strategy

Analysis for the completion of the proposed aims included multilevel modeling and social network analysis. In all aims individual- and camp-level sources of variation in sexual risk behaviors were accounted for using multilevel models, given the nested data structure and the fact that I hypothesized both individual and camp-level determinants of sexual risk.

Descriptive analysis. I began analysis by describing the means and proportions of the individual-level and camp-level independent variables, dependent variables, and covariates in the sample. I created histograms of the continuous predictors of anxiety and depression, and described the means of these continuous predictors and proportions of the categorical outcomes by camp to further assess the level of variance in these key variables [96].

Missing data. To address missing data from the behavioral survey (primarily due to attrition), I applied sequential multiple imputation using the fully conditional specification in *proc MI*. Forty imputations were created using a linear regression specification for continuous variables and a logistic regression specification for categorical variables. To account for missing network ties in the quadratic assignment procedure discussed below, I conducted imputation by reconstruction as recommended by Huisman [97]. Specifically, I used random imputation of ties proportional to the observed network density (i.e., the probability of a tie is equal to the observed density of each network), as described by Huisman as an extension of Stork and Richard's method of reconstruction [97].

Aim 1 analysis

Aim 1, Hypothesis 1

Young men experiencing increased symptoms of anxiety and depression from time 1 to time 2 will report less frequent condom use and be more likely to report engaging in sexual partner concurrency at time 2, controlling for time 1 behaviors, than young men experiencing decreased symptoms of anxiety and depression.

To test this hypothesis, I fit multilevel models and regressed time two sexual risk behaviors on time one sexual risk behaviors, change score measures of mental health (time 2 – time 1), and baseline values of the covariates listed above. Multilevel modeling was used in all aims to adjust for the nested data structure by camp. I compared the variance from this model to that of the null model to assess the proportion of the variance in sexual risk behaviors explained by level-one predictors. The formulas for the respective null models for condom use and concurrency are as follows:

$$\begin{aligned} \text{Level 1: } \text{CumuloLogCondUse}_{ij} &= \beta_{0j} + r_{ij} & r_{ij} &\sim N(0, \sigma^2) \\ \text{Level 2: } \beta_{0j} &= \gamma_{00} + u_{0j} & u_{0j} &\sim N(0, \tau_{00}) \end{aligned}$$

$$\begin{aligned} \text{Level 1: } \text{LogCncr}_{ij} &= \beta_{0j} + r_{ij} & r_{ij} &\sim N(0, \sigma^2) \\ \text{Level 2: } \beta_{0j} &= \gamma_{00} + u_{0j} & u_{0j} &\sim N(0, \tau_{00}) \end{aligned}$$

The intraclass correlation (ICC) was calculated as the within group variance (σ^2), over the total variance ($\sigma^2 + \tau_{00}^2$). The computed ICCs specified the proportion of the total variance in each sexual risk behavior which could be attributed to camp membership [98]. Using this ICC and estimates of within and between group variance from the null model as a point of comparison of the proportion of the variance explained by subsequent models, I continued my analysis by testing and comparing the fit of linear and non-linear models, as indicated by previous evidence of a non-linear relationship between depression and sexual risk [13-15].

Grand mean centering. Following imputation, I grand mean centered all continuous variables to be included in Aim 1 analyses, including anxiety and depression. Because baseline ICCs for these variables were low (0.046 and 0.047 for depression and anxiety, respectively), and as level 1 variation was of primary interest for this aim, continuous variables were centered using the grand mean rather than the camp mean.

Assessing collinearity. Because of the frequent comorbidity between anxiety and depression, I was concerned about a possible level of collinearity between measurements of their symptoms (the correlation between symptoms of anxiety and depression was 0.76 at baseline and 0.74 at the follow-up) which would limit the ability to interpret the independent effects of anxiety and depression when estimated simultaneously. For this reason, I tested three models for each sexual behavior dependent variable (for a total of six models): 1) change in anxiety symptoms only; 2) change in depression symptoms only; and 3) change in both anxiety and depression symptoms. I compared the parameter estimates and confidence intervals of models 1 and 2 to those in model 3 to assess the effects of the two correlated primary predictors.

Linear models. All models were fit using *proc glimmix*, quadrature estimation (using 15 quadrature points), and logit and cumulative logit link functions (for dichotomous concurrency, and three-level condom use, respectively). For all models the dependent variable was sexual risk (condom use or concurrency) measured at the follow-up controlling for baseline sexual risk and the covariates listed above. The primary predictor was change in anxiety or depression (baseline score subtracted from the follow-up score).

Aim 1: Linear model equations		
	Condom use	Concurrency
Anxiety	$\begin{aligned} \mathbf{CumuloLogCondUse}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(Anx_{ij,t} - Anx_{ij,t-1}) + \\ & \gamma_{20}Age_{ij,t-1} + \gamma_{30}Edu_{ij,t-1} + \\ & \gamma_{40}SES_{ij,t-1} + \gamma_{50}MaritalStatus_{ij,t-1} + \\ & \gamma_{60}CondUse_{ij,t-1} + \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$	$\begin{aligned} \mathbf{LogCncr}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(Anx_{ij,t} - Anx_{ij,t-1}) + \gamma_{20}Age_{ij,t-1} + \\ & \gamma_{30}Edu_{ij,t-1} + \gamma_{40}SES_{ij,t-1} + \\ & \gamma_{50}MaritalStatus_{ij,t-1} + \gamma_{60}Cncr_{ij,t-1} + \\ & \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$
Depression	$\begin{aligned} \mathbf{CumuloLogCondUse}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(Dpr_{ij,t} - Dpr_{ij,t-1}) + \gamma_{20}Age_{ij,t-1} + \\ & \gamma_{30}Edu_{ij,t-1} + \gamma_{40}SES_{ij,t-1} + \\ & \gamma_{50}MaritalStatus_{ij,t-1} + \\ & \gamma_{60}CondUse_{ij,t-1} + \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$	$\begin{aligned} \mathbf{LogCncr}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(Dpr_{ij,t} - Dpr_{ij,t-1}) + \gamma_{20}Age_{ij,t-1} + \\ & \gamma_{30}Edu_{ij,t-1} + \gamma_{40}SES_{ij,t-1} + \\ & \gamma_{50}MaritalStatus_{ij,t-1} + \gamma_{60}Cncr_{ij,t-1} + \\ & \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$

Non-linear models. As indicated by previous studies of the relationship between depression and sexual risk [13-15], I tested non-linear specifications of mental health predictors for all hypothesized relationships to compare to the linear models described above. As prior evidence indicated a concave curvilinear relationship, I tested a quadratic specification of the mental health predictors. As these quadratic terms were not statistically significant, they were excluded from the final models.

Limitations. Respondents' willingness to report sexual risk behaviors may have been associated with the social acceptability of such an acknowledgment. In addition, reports of sexual risk behaviors were retrospective, and thus recall bias may have been an issue. However, the coding of the condom use and concurrency variables were designed to minimize the influence of recall bias, as discussed above. The HSCL-25 scale which was used to measure anxiety and depression was developed in a different cultural context than the study setting. Given that this scale has been previously validated in Tanzania as mentioned above [51, 52], I felt comfortable with the theoretical validity of the scale's measurement of anxiety and depression symptoms in this population. Further, the two time points as measured a year apart did not allow me to establish whether affective manifestations of anxiety and depression directly precede decisions to engage in risky sexual behaviors. Though there is an established temporal

relationship between changes in internalizing symptoms and in sexual risk in this study, event-level data are needed to establish the precise temporal relationship [83]. Within the limitations of the data available, the hypotheses as tested allowed me to establish whether changes in anxiety and depression were associated with sexual behaviors in this population.

Aim 2 analysis

Aim 2, Hypothesis 2a
<i>Young men’s sexual risk behaviors will be more correlated with those of friends than with those of other members of their camp network.</i>
Aim 2, Hypothesis 2b
<i>The relationship between mental health and sexual risk will be moderated by peer sexual risk behavior norms such that the relationship will be stronger for young men exposed to riskier peer norms than for men exposed to less risky peer norms.</i>

In preliminary analyses for Aim 2 I described the structural measures of camp networks and further described the size, average in/out degree, and average degree by relationship type (acquaintance, friend, someone I don’t get along with) of young men’s friendship networks (ego-networks) at baseline.

Univariate network correlations

Next I tested network correlations for each dependent variable of interest (condom use and concurrency). I tested these correlations within each of the 59 networks in using a Quadratic Assignment Procedure (QAP). QAP is a non-parametric procedure for significance testing which is used to infer social influence by relating measures of structural similarity (in this case, structural similarity is defined by the existence of friendship tie) between two network members to a measure of their similarity on variables of interest [77]. QAP runs the specified model through multiple iterations by randomly permuting the

rows and columns of model matrices each time. This process produces an empirical distribution of the model coefficients against which to compare model estimates for hypothesis testing. Given a significance level of 0.05, an observed parameter is determined to be statistically significant if it is greater than 95 percent of the values in the empirical distribution based on 2000 iterations [77]. QAP is an extremely robust procedure because its assumptions are only those of the data generation process; all biases in the data are also seen in the permuted population [77].

Interactions between mental health and peer norms

To test the hypothesis that the relationship between mental health and sexual risk is moderated by the influence of peer sexual risk behavior norms, I built upon the main effect models used to assess hypothesis 1, and continued to utilize multilevel modeling to adjust estimates for the nested data structure by camp. For each model from Aim 1, I assessed the interaction between mental health and peer norm scores. Where these interaction terms were significant, I probed each significant interaction found by modeling the focal effect at the mean, one standard deviation above the mean, and one standard deviation below the mean of the moderator variable scores [99].

To adjust standard errors due to the dependence of observations in models including norms based on friends' self-reported behaviors, I included controls for subgroup clustering within each camp. As the same person could be nominated by multiple individuals as a friend, friendship cliques within the camps could lead to unobserved dependence within the data. To identify clique subgroups, I created a distance matrix for each camp where the cell values were the number of steps between each dyad. With each of these matrices I performed a principal components analysis to detect structurally significant subgroups within the camp, calculated the factor loading of each individual on each of the principal components, and included these terms in the regression model as a control [100]. Models to test these hypotheses are specified in the formulas below:

Aim 2: Interaction model equations*		
	Condom use	Concurrency
Anxiety	$\begin{aligned} \text{CumuloLogCondUse}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(\text{Anx}_{ij,t} - \text{Anx}_{ij,t-1}) + \\ & \gamma_{20}(\text{Norm}_{ij,t} - \text{Norm}_{ij,t-1}) + \\ & \gamma_{30}(\text{Anx}_{ij,t} - \text{Anx}_{ij,t-1})(\text{Norm}_{ij,t} - \text{Norm}_{ij,t-1}) + \\ & \gamma_{40}\text{Age}_{ij,t-1} + \gamma_{50}\text{Edu}_{ij,t-1} + \gamma_{60}\text{SES}_{ij,t-1} + \\ & \gamma_{70}\text{MaritalStatus}_{ij,t-1} + \\ & \gamma_{80}\text{CondUse}_{ij,t-1} + \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$	$\begin{aligned} \text{LogCncr}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(\text{Anx}_{ij,t} - \text{Anx}_{ij,t-1}) + \\ & \gamma_{20}(\text{Norm}_{ij,t} - \text{Norm}_{ij,t-1}) + \\ & \gamma_{30}(\text{Anx}_{ij,t} - \text{Anx}_{ij,t-1})(\text{Norm}_{ij,t} - \text{Norm}_{ij,t-1}) + \\ & \gamma_{40}\text{Age}_{ij,t-1} + \gamma_{50}\text{Edu}_{ij,t-1} + \gamma_{60}\text{SES}_{ij,t-1} + \\ & \gamma_{70}\text{MaritalStatus}_{ij,t-1} + \gamma_{80}\text{Cncr}_{ij,t-1} + \\ & \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$
Depression	$\begin{aligned} \text{CumuloLogCondUse}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(\text{Dpr}_{ij,t} - \text{Dpr}_{ij,t-1}) + \\ & \gamma_{20}(\text{Norm}_{ij,t} - \text{Norm}_{ij,t-1}) + \\ & \gamma_{30}(\text{Dpr}_{ij,t} - \text{Dpr}_{ij,t-1})(\text{Norm}_{ij,t} - \text{Norm}_{ij,t-1}) + \\ & \gamma_{40}\text{Age}_{ij,t-1} + \gamma_{50}\text{Edu}_{ij,t-1} + \gamma_{60}\text{SES}_{ij,t-1} + \\ & \gamma_{70}\text{MaritalStatus}_{ij,t-1} + \\ & \gamma_{80}\text{CondUse}_{ij,t-1} + \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$	$\begin{aligned} \text{LogCncr}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(\text{Dpr}_{ij,t} - \text{Dpr}_{ij,t-1}) + \\ & \gamma_{20}(\text{Norm}_{ij,t} - \text{Norm}_{ij,t-1}) + \\ & \gamma_{30}(\text{Dpr}_{ij,t} - \text{Dpr}_{ij,t-1})(\text{Norm}_{ij,t} - \text{Norm}_{ij,t-1}) + \\ & \gamma_{40}\text{Age}_{ij,t-1} + \gamma_{50}\text{Edu}_{ij,t-1} + \gamma_{60}\text{SES}_{ij,t-1} + \\ & \gamma_{70}\text{MaritalStatus}_{ij,t-1} + \gamma_{80}\text{Cncr}_{ij,t-1} + \\ & \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$

*models testing moderation by peer-reported behaviors include additional covariates reflecting loadings on principle components derived from camp distance matrices: $\sum_k \lambda_{ik} \eta_k$

Aim 3 analysis

<p>Aim 3, Hypothesis 3a</p> <p><i>Young men's centrality within their camp social network will moderate the relationship between mental health and sexual risk behaviors such that the relationship will be weaker for men with higher centrality than for those with lower centrality.</i></p>
<p>Aim 3, Hypothesis 3b</p> <p><i>Network social cohesion will moderate the relationship between mental health and sexual risk behaviors such that the relationship will be weaker for young men in camps with higher levels of social cohesion than for those in camps with lower levels of social cohesion.</i></p>

To test these hypotheses, I built off of the main effects models from Aim 1 and include measures of centrality, social cohesion, and respective interaction terms between these network measures and anxiety or depression to test the hypothesized moderating effects. Baseline measures of centrality and social cohesion were used in these models.

Hypothesis 3a. Building upon the main effect models used to assess hypothesis 1, to test the individual level moderator of centrality I added the centrality variable to the model. Following this, I added an interaction term for the mental health predictor and centrality variable to the model.

Hypothesis 3b. To evaluate moderation by camp social cohesion of the relationship between mental health and sexual risk, I fit two-level, slopes as outcomes models including camp social cohesion and the interaction between mental health and social cohesion as predictors.

If a significant interaction was found in testing either hypothesis 3a or 3b, I intended to probe each significant interaction by modeling the main effect at the mean, one standard deviation above the mean, and one standard deviation below the mean of the moderator variable scores [99]. No such significant interaction was found. All models were fit using *proc glimmix*, quadrature estimation (using 15 quadrature points), and logit and cumulative logit link functions (for dichotomous concurrency, and three-level condom use, respectively). Models to test these hypotheses are specified below:

Aim 3, Hypothesis 3a: Centrality interaction model equations		
	Condom use	Concurrency
Anxiety	$\begin{aligned} \text{CumuloLogCondUse}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(Anx_{ij,t} - Anx_{ij,t-1}) + \gamma_{20}Centr_{ij,t-1} + \\ & \gamma_{30}Centr_{ij,t-1}(Anx_{ij,t} - Anx_{ij,t-1}) + \\ & \gamma_{40}Age_{ij,t-1} + \gamma_{50}Edu_{ij,t-1} + \gamma_{60}SES_{ij,t-1} + \\ & \gamma_{70}MaritalStatus_{ij,t-1} + \\ & \gamma_{80}CondUse_{ij,t-1} + \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$	$\begin{aligned} \text{LogCncr}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(Anx_{ij,t} - Anx_{ij,t-1}) + \gamma_{20}Centr_{ij,t-1} + \\ & \gamma_{30}Centr_{ij,t-1}(Anx_{ij,t} - Anx_{ij,t-1}) + \\ & \gamma_{40}Age_{ij,t-1} + \gamma_{50}Edu_{ij,t-1} + \\ & \gamma_{60}SES_{ij,t-1} + \gamma_{70}MaritalStatus_{ij,t-1} + \\ & \gamma_{80}Cncr_{ij,t-1} + \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$
Depression	$\begin{aligned} \text{CumuloLogCondUse}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(Dpr_{ij,t} - Dpr_{ij,t-1}) + \gamma_{20}Centr_{ij,t-1} + \\ & \gamma_{30}Centr_{ij,t-1}(Dpr_{ij,t} - Dpr_{ij,t-1}) + \\ & \gamma_{40}Age_{ij,t-1} + \gamma_{50}Edu_{ij,t-1} + \gamma_{60}SES_{ij,t-1} + \\ & \gamma_{70}MaritalStatus_{ij,t-1} + \\ & \gamma_{80}CondUse_{ij,t-1} + \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$	$\begin{aligned} \text{LogCncr}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(Dpr_{ij,t} - Dpr_{ij,t-1}) + \gamma_{20}Centr_{ij,t-1} + \\ & \gamma_{30}Centr_{ij,t-1}(Dpr_{ij,t} - Dpr_{ij,t-1}) + \\ & \gamma_{40}Age_{ij,t-1} + \gamma_{50}Edu_{ij,t-1} + \\ & \gamma_{60}SES_{ij,t-1} + \gamma_{70}MaritalStatus_{ij,t-1} + \\ & \gamma_{80}Cncr_{ij,t-1} + \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$

Aim 3, Hypothesis 3b: Camp cohesion interaction model equations		
	Condom use	Concurrency
Anxiety	$\begin{aligned} \text{CumuloLogCondUse}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(Anx_{ij,t} - Anx_{ij,t-1}) + \gamma_{20}Cohes_{ij,t-1} + \\ & \gamma_{30}Cohes_{ij,t-1}(Anx_{ij,t} - Anx_{ij,t-1}) + \\ & \gamma_{40}Age_{ij,t-1} + \gamma_{50}Edu_{ij,t-1} + \gamma_{60}SES_{ij,t-1} + \\ & \gamma_{70}MaritalStatus_{ij,t-1} + \\ & \gamma_{80}CondUse_{ij,t-1} + \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$	$\begin{aligned} \text{LogCncr}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(Anx_{ij,t} - Anx_{ij,t-1}) + \gamma_{20}Cohes_{ij,t-1} + \\ & \gamma_{30}Cohes_{ij,t-1}(Anx_{ij,t} - Anx_{ij,t-1}) + \\ & \gamma_{40}Age_{ij,t-1} + \gamma_{50}Edu_{ij,t-1} + \\ & \gamma_{60}SES_{ij,t-1} + \gamma_{70}MaritalStatus_{ij,t-1} + \\ & \gamma_{80}Cncr_{ij,t-1} + \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$
Depression	$\begin{aligned} \text{CumuloLogCondUse}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(Dpr_{ij,t} - Dpr_{ij,t-1}) + \gamma_{20}Cohes_{ij,t-1} + \\ & \gamma_{30}Cohes_{ij,t-1}(Dpr_{ij,t} - Dpr_{ij,t-1}) + \\ & \gamma_{40}Age_{ij,t-1} + \gamma_{50}Edu_{ij,t-1} + \gamma_{60}SES_{ij,t-1} + \\ & \gamma_{70}MaritalStatus_{ij,t-1} + \\ & \gamma_{80}CondUse_{ij,t-1} + \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$	$\begin{aligned} \text{LogCncr}_{ij,t} = & \gamma_{00} + \\ & \gamma_{10}(Dpr_{ij,t} - Dpr_{ij,t-1}) + \gamma_{20}Cohes_{ij,t-1} + \\ & \gamma_{30}Cohes_{ij,t-1}(Dpr_{ij,t} - Dpr_{ij,t-1}) + \\ & \gamma_{40}Age_{ij,t-1} + \gamma_{50}Edu_{ij,t-1} + \\ & \gamma_{60}SES_{ij,t-1} + \gamma_{70}MaritalStatus_{ij,t-1} + \\ & \gamma_{80}Cncr_{ij,t-1} + \gamma_{01}Tx_j + u_{0j} + r_{ij} \end{aligned}$

3.5 Sample size and power

Using baseline data, I computed the intraclass correlation (ICC) for condom use and concurrency by camp (0.060 and 0.034, respectively). Using these estimates and an average camp size of 21 men, simulation studies were conducted to assess the power of the proposed study for Aim 1. For a significance level of 0.05, there was 80% power to detect an association between mental health and condom use provided the true odds ratio of always using condoms was 0.60 or lower (further from the null) for men categorized as displaying depression/anxiety versus men who are not displaying depression/anxiety. There was also 80% power to detect an association between mental health and concurrency provided the true odds ratio of concurrency is 1.65 or higher (further from the null) for men categorized as displaying depression/anxiety versus men who are not displaying depression/anxiety.

For the correlation hypotheses related to Aim 2, at a significance level of 0.05 there was 80% power to detect correlations as low as 0.12 and 0.13 for condom use and concurrency, respectively. For the moderation hypotheses related to Aims 2 and 3, statistical power was expected to be sufficient based on the simulation results of the power of cross-level interaction tests in multilevel studies presented by Mathieu et al [101]. Mathieu et al. found that larger level one sample sizes (greater than

18) along with larger level two sample sizes (greater than 35), often surpassed power of 80% in simulations with varying magnitudes of the direct cross-level effects as well as standard deviations of the level one slope coefficients [101].

CHAPTER 4: PAPER 1

CHANGES IN ANXIETY AND DEPRESSION SYMPTOMS PREDICT SEXUAL RISK BEHAVIORS AMONG YOUNG MEN LIVING IN DAR ES SALAAM, TANZANIA

4.1 Background

There are 4 million young people ages 15-24 living with HIV [102], 85% of whom live in sub-Saharan Africa [103]. AIDS-related deaths among youth rose by 50% between 2005 and 2012 and adolescents and young adults account for a growing proportion of African populations [103], making the need to target and engage youth in HIV prevention increasingly important. 40 percent of new infections in Tanzania occur among 16-24 year olds [1], and 17 percent of women and 8 percent of men ages 15-19 years are HIV-infected in Tanzania [3]. Young men are important targets in preventing HIV transmission in this context as gender norms position them to control the terms and conditions of sexual relationships [32], and encourage them to engage in high risk sexual behaviors including inconsistent condom use and sexual partner concurrency [1, 33-36]. Among young men in Dar es Salaam, the commercial capital of Tanzania, the proportion of young men reporting condom use at last sex seems to decline over adolescence (92% of 15-year-olds compared to 70% of 19-year-olds) [29]. and the proportion reporting concurrent sexual partnerships increases with age, from 5 percent at age 15 to 44% by age 19 [29]. This trend is consistent with national studies in Tanzania; half of sexually active youth ages 15-24 surveyed in 2010 did not use a condom at last intercourse, and nearly one-third reported concurrent partners [4].

Anxiety and depression are important correlates of sexual risk [5, 6, 8-10, 104], and may influence risk through multiple mechanisms including substance use [10], maladaptive coping to deal

with stress [47], and impaired decision making [48]. Cross-sectional associations have repeatedly been found between both anxiety and depression, and sexual risk behaviors [5-7, 9, 10], but we have little understanding of the longitudinal association between these anxiety, depression, and sexual risk [8, 11, 12, 49, 105], particularly from low-income or high HIV-prevalence contexts as the bulk of the extant evidence comes from high income contexts [5, 8, 10-15]. Due to its prevalence and frequent comorbidity with depression [106], understanding anxiety as a predictor of sexual risk is particularly needed in this context, as there has been only one study examining anxiety as a predictor of sexual risk in a sub-Saharan Africa to our knowledge [7]. Finally, given the importance of young men in HIV prevention we need better evidence of these risk relationships among young men who have sex with women, a literature which is lacking. To address these gaps in the literature, we assessed the longitudinal relationship between symptoms of anxiety and depression and sexual risk behaviors among a population of socioeconomically marginalized young men in Dar es Salaam. The results of this study provide much needed information for the development of effective HIV and sexual risk prevention interventions relevant to the growing population of male youth in sub-Saharan urban areas.

4.2 Methods

Study context

This study was conducted in the context of an ongoing HIV prevention trial, *A Multilevel Intervention to Reduce HIV Risk Among Networks of Men in Tanzania* (PI: Suzanne Maman; 1R01MH098690-01), a cluster randomized trial of a microfinance and health leadership intervention to prevent sexually transmitted infections and intimate partner violence [107]. Participants in this trial are members of venues known as “camps” in Dar es Salaam where men socialize and engage in small scale enterprise [28]. Most camp members are not formally employed and who spend several hours each day at their camp [28].

Sampling and data collection

We identified camps for inclusion in the trial in four wards (equivalent to U.S. census tracts) of Dar es Salaam (Manzese, Tandale, Mwananyamala, and Mabibo) using an adaptation of PLACE (Priorities for Local AIDS Control Efforts) methodology [108]. To be eligible for inclusion in the trial, camps had to have between 20 and 80 members, have been in existence for at least one year prior to the baseline assessment, and report no violent incidents with weapons in the past 6 months. A total of 303 camps were verified, of which 205 were eligible. 60 camps were randomly selected for inclusion in the study. Through member rosters completed by the leaders of these camps, 1581 male members were identified and assessed for eligibility. To be eligible men had to: 1) be a registered camp member for at least three months; 2) plan on residing in Dar es Salaam for the next 30 months; 3) be 15 years or older; 4) visit the camp at least once per week; and 5) be willing to provide contact information for self and two family members or friends.

Eligible participants were asked to provide written consent, and consenting participants completed the baseline assessment in fall 2013 and a follow up assessment 12 months after the launch of the intervention. Both questionnaires were administered by trained Tanzanian interviewers in Swahili using computer assisted personal interviewing (CAPI). The interviews lasted approximately 60-90 minutes. A total of 1,258 men completed the baseline behavioral assessment, after which camp members from one camp (n=9) were removed from the study because of new information rendering them ineligible for participation, resulting in a final baseline sample of 1,249 men within 59 camps. 978 men in the 59 camps completed the follow-up assessment for 78% retention.

Measures

Symptoms of anxiety and depression were measured using a version of the Hopkins Symptom Checklist-25 (HSCL-25)[85] that had previously been translated and validated in Tanzania [86, 87]. Participants

rated a total of 25 symptoms (10 related to anxiety, 15 to depression) rated on a 4-point Likert-type scale. Anxiety and depression scores were calculated by taking the mean of the corresponding 10 and 15 items, respectively. In the baseline sample both subscales showed good internal consistency ($\alpha = 0.94$ for anxiety, $\alpha = 0.91$ for depression). Where depression and anxiety are described dichotomously in the results, the recommended cutoff of 1.75 was used for clinical caseness [88].

Condom use was measured as an ordered-categorical variable created from men's self-report of condom use over the 3 most recent sexual partners (number of sex acts and number of times condoms used over the most recent month of the relationship with each partner). Using the proportion of reported sex acts where condoms were used, participants were assigned to one of three categories: "never use" (0% use), "some use" (greater than 0%, less than 100%), or "always use" (100%). This categorical approach was preferred to a continuous variable in the interest of minimizing the effect of recall bias, and over a dichotomous variable per the recommendations of Noar et al [83]. Sexual concurrency was evaluated by self-report of any overlapping sexual partnerships. Participants were asked to enumerate their 3 most recent relationships over the past 12 months and to report if they had sex with anyone else during any of these partnerships. This measure was developed following best practices recently recommended by USAID [84].

Covariates included in all analyses include age, education level, economic status, marital status, and treatment condition. Age was calculated based on reported date of birth, or when not available the reported age in years. Participants reported the highest level of education they had completed and education responses were collapsed into three categories: primary school or less (no education, Standard 4 or less, or Standard 5-7); some secondary school (Form 1, Form 2, or Form 3); or secondary school completed or greater (Form 4 or Greater than Form 4). Socioeconomic status (SES) was evaluated through the Filmer Pritchett Wealth Index [91]. Participants were asked to indicate which of 10 possible assets they owned [92] and a composite score was created by weighting each asset by its factor loading

on the first component in a principle components analysis [91]. The weighted composite score for each participant was categorized into terciles based on the entire baseline sample (the lowest 33% as “lowest SES”, the highest 33% as “highest SES,” and the remainder as “middle SES”). Marital status was evaluated by asking men if they had ever been married. Finally, as the intervention being evaluated was designed to affect condom use and sexual partner concurrency, treatment condition was included as a covariate to account for this design effect in all analyses.

Analysis

All statistical analyses were conducted in SAS v 9.4 and used a 2-sided significance level of 0.05. First we described demographic characteristics of the participants and levels of variables of interest at baseline and at the follow-up. To address missing data (primarily due to attrition), we applied sequential multiple imputation using the fully conditional specification in *proc MI*. Forty imputations were created using a linear regression specification for continuous variables and a logistic regression specification for categorical variables. To test the primary hypothesis while accounting for dependence due to clustering within camps, we fit multilevel models with a generalized link function. All models were fit using *proc glimmix* with quadrature estimation, random intercepts, and logit and cumulative logit link functions (for dichotomous concurrency, and three-level condom use, respectively).

All models assessed the association between the dependent variable of reported sexual behavior at the follow-up (condom use or concurrency) and the independent variable of within-person change in symptoms of anxiety or depression, controlling for baseline sexual behavior and the covariates listed above. Change scores of symptoms of anxiety and depression were chosen to increase the plausibility of causal inferences about the observed temporal associations between men’s symptoms and sexual risk behaviors. Because of the frequent comorbidity between anxiety and depression, we were concerned about a possible level of collinearity between measurements of their symptoms (the

correlation between symptoms of anxiety and depression was 0.76 at baseline and 0.74 at the follow-up). For this reason, we tested three models for each sexual behavior dependent variable (for a total of six models): 1) Change in anxiety symptoms only; 2) Change in depression symptoms only; and 3) Change in both anxiety and depression symptoms. We compared the parameter estimates and confidence intervals of models 1 and 2 to those in model 3 to assess the effects of our two primary predictors.

Ethical Review

The study was approved by the ethical review committees at the University of North Carolina at Chapel Hill and Muhimbili University of Health and Allied Sciences in Dar es Salaam, Tanzania. Individual written informed consent was obtained from all study participants.

4.3 Results

1249 men were interviewed at baseline, of whom 1113 (89%) reported being sexually active. These 1113 men were included in the analyses presented below.

Participant characteristics

Sexually active men interviewed at baseline had an average age of 27 years (range: 15 to 59). Over half had a primary school education or less (59%), nearly a third had graduated from secondary school (31%), and the remaining 11% had some secondary school but had not graduated. A quarter of the men had ever been married (25%) and 38% had children.

Table 4. Baseline Participant Characteristics (n=1113)^a

	Total
Age (y) ^{***}	26.8 ± 7.1
Currently in school	97 (8.7%)
Education level (ref = less than primary school completed)	
Primary school or less	652 (58.7%)
Some secondary school	116 (10.5%)
Secondary school completed or greater	342 (30.8%)
Socioeconomic status	
Lowest	291 (26.2%)
Middle	435 (39.1%)
Highest	386 (34.7%)
Ever married	277 (25.0%)
Has children	423 (38.0%)

^aData are expressed as No.(%) or Mean ± SD

Change in symptoms of anxiety and depression and sexual behaviors

Men had an average score of 1.4 (range 1 to 4 with higher scores indicating more severe symptoms) for both anxiety and depression symptoms at both baseline and at the follow-up assessment (Table 5). At baseline 21% reported clinically significant symptoms of depression and 19% reported clinically significant symptoms of anxiety based on common clinic cutoffs (score ≥ 1.75) [90]. At the follow-up 20% and 16% of respondents met the criteria for depression and anxiety, respectively. Fifteen percent of men showed symptoms of both anxiety and depression at baseline compared to 12% of respondents at the follow-up. The mean within-person change in depression and anxiety scores were both close to zero, but there was substantial variation in change scores (-0.03 ± 0.76 for depression and -0.03 ± 0.72 for anxiety). The within-person correlation between baseline and follow-up symptoms was 0.08 for anxiety and 0.13 for depression. The correlation between symptoms of anxiety and depression was high at both

time points: 0.76 at baseline and 0.74 at the follow-up. Furthermore, the correlation between within-person change in anxiety and depression symptoms was 0.73.

At the sample level, there were relatively similar levels of condom use and concurrency across the two time points; about half of men reported never using condoms at both baseline and the follow-up (53% and 52%, respectively). More men reported always using condoms at baseline than at the follow-up (33% and 26%, respectively). 14% of men reported sometimes using condoms at baseline, and this proportion increased to 22% at the follow-up. Within individuals there were significant changes in condom use; only 325 (48%) of men remained in the same condom use category at the follow-up as compared to baseline (Table 6). Men who reported no condom use at baseline were the most likely to maintain the same use status at the follow-up (216 men, 61% of baseline non-users). Only 26% of men with some use at baseline reported the same level of use at the follow-up, with the greatest number changing to not using condoms (54 men, 53% of baseline sometimes users). Among baseline always users, nearly as many men reported no condom use at the follow-up (82 men, 37% of baseline always users) as reported still always using condoms (83 men, 38% of baseline always users). The within-person correlation between baseline and follow-up condom use was 0.21. Many more men reported concurrency at the follow-up (262, 32%) than at baseline (193, 20%; Table 5). 30% of men who were not concurrent at baseline reported concurrency at the follow-up (Table 7) while half (49%) of men who were concurrent at baseline reported concurrency again at the follow-up. The within-person correlation between baseline and follow-up concurrency was 0.16.

Table 5. Cross-sectional description of symptoms of anxiety and depression and sexual risk^a

	Baseline	Follow-up
Depression score	1.43 ± 0.57	1.42 ± 0.56
Anxiety score	1.38 ± 0.51	1.36 ± 0.53
Depression (score ≥ 1.75)	237 (21.3%)	174 (20.0%)
Anxiety (score ≥ 1.75)	206 (18.5%)	141 (16.2%)
Both depression and anxiety (both scores ≥ 1.75)	164 (14.7%)	101 (11.6%)
Condom use		
Never	491 (52.7%)	408 (51.6%)
Sometimes	133 (14.3%)	176 (22.3%)
Always	308 (33.1%)	207 (26.2%)
Concurrency	193 (20.2%)	262 (32.1%)

^aData are expressed as No. (%) or Mean ± SD

Table 6. Condom use change

		Follow-up condom use		
		None	Some	Always
Baseline condom use	None	216 (59.7%)	73 (20.2%)	73 (20.2%)
	Some	54 (53.5%)	26 (25.7%)	21 (20.8%)
	Always	82 (37.3%)	55 (25.0%)	83 (37.7%)

Table 7. Concurrency change

		Follow-up concurrency	
		No	Yes
Baseline concurrency	No	400 (69.9%)	172 (30.1%)
	Yes	76 (51.0%)	73 (49.0%)

Anxiety models

The random intercepts models for anxiety (Table 8; Model 1) indicated that changes in anxiety symptoms were significantly associated with both condom use and concurrency at the follow-up, controlling for baseline behavior and covariates listed in the Methods. Specifically, men who experienced an increase in anxiety symptoms reported lower condom use levels and had higher odds of

concurrency at the follow-up than did men with decreasing anxiety symptoms. For each one-unit increase in anxiety symptoms, there was an estimated 18% decrease in the odds of a higher level of condom use (aOR=0.82; 95% CI: 0.68, 0.99). For each one-unit gain in anxiety symptoms, there was an estimated 67% increase in the odds of sexual concurrency (aOR=1.67; 95% CI: 1.34, 2.08).

Depression models

The random intercepts models for depression (Table 8; Model 2) indicated that changes in depression symptoms were also significantly associated with both condom use and concurrency at the follow-up, controlling for baseline behavior and covariates listed in the Methods. Specifically, men who experienced an increase in depression symptoms reported lower condom use levels and had higher odds of concurrency at the follow-up than did men with decreasing depression symptoms. For each one-unit increase in depression symptoms, there was an estimated 24% decrease in the odds of a higher level of condom use (aOR=0.76; 95% CI: 0.64, 0.90). For each one-unit gain in depression symptoms, there was an estimated 60% increase in the odds of sexual concurrency (aOR=1.60, 95% CI: 1.30, 1.97).

Independent effects of anxiety and depression

To evaluate the relative strength of the association of anxiety and depression with each sexual behavior, we tested additional models for condom use and concurrency including both anxiety and depression change as predictors in the same models (Table 8; Model 3). The width of the confidence intervals for the estimated effects of anxiety and depression on condom use showed little change between the separate and combined models, indicating that collinearity had minimal effect on model fit. There was a larger widening of the confidence intervals in the combined concurrency model, indicating that precision was negatively but modestly affected by collinearity between anxiety and depression. When the effects of anxiety and depression were estimated together, only depression was significantly associated with

condom use, and not anxiety. For concurrency, when anxiety and depression effects were estimated together, anxiety and depression change predictors remained significant or marginally significant. This indicates that both anxiety and depression symptoms may independently affect concurrency, but the effect of each is attenuated when controlling for the other. On the other hand, observed association between anxiety symptoms and condom use may be explained by anxiety's high level of covariance with depression.

Table 8. Aim 1 model results

Model	Condom use		Concurrency	
	aOR (95%CI)	p	aOR (95%CI)	p
1. Anxiety change only	0.82 (0.68, 0.99)	0.040	1.67 (1.34, 2.08)	<.0001
2. Depression change only	0.76 (0.64, 0.90)	0.002	1.60 (1.30, 1.97)	<.0001
3. Both anxiety & depression				
<i>Anxiety change</i>	1.02 (0.77, 1.15)	0.873	1.40 (1.04, 1.89)	0.026
<i>Depression change</i>	0.75 (0.58, 0.97)	0.026	1.27 (0.96, 1.67)	0.095

Note: Covariates in all models include treatment condition, age, education level, SES, and ever having been married.

4.4 Discussion

In this sample of young male members of "camps" in Dar es Salaam, we found that many men experienced clinically significant symptoms of anxiety and depression (19% and 21%, respectively at baseline), and reported significant levels of partner concurrency and inconsistent condom use from an HIV prevention perspective. We found that changes in anxiety and depression were significantly associated with both condom use and concurrency at the follow-up controlling for baseline behavior. A secondary model indicated that anxiety and depression may independently affect concurrency but depression may be the primary predictor of condom use, with the observed relationship between anxiety and condom use being likely attributable to the covariance between anxiety and depression

symptoms. These findings provide important evidence of the longitudinal association between symptoms of anxiety and depression and HIV risk in a primarily heterosexual population of young men in a sub-Saharan urban setting.

Though the present study did not assess potential mechanisms explaining the observed relationships, there are multiple theorized pathways through which negative affect in the form of symptoms of anxiety and depression may lead to sexual risk behaviors. Negative affective states may hamper one's ability to self-regulate and change thoughts, emotions, and behaviors [109, 110]. Without this ability to self-regulate, individuals experiencing anxiety and depression may face greater challenges in avoiding risky sexual behaviors. Furthermore, when faced with negative emotions they may be motivated to act to relieve the negative emotion [111, 112], which can be achieved through self-gratifying behaviors (e.g. sex with a secondary partner) which serve as a distraction from the negative emotions [112-118]. Finally, people experiencing depressed emotions may have decreased motivation to care for themselves and to avoid risky behaviors [119]. Future research is needed to determine which of these mechanisms is in operation in this population.

These mechanisms may help to explain our finding that depression and not anxiety seemed to be independently associated with condom use. Because of the hopelessness, sense of futility, and tendency toward self-destructive behaviors associated with depression [120], men experiencing greater levels of depression may be less likely to use condoms. On the other hand, men with symptoms of anxiety may have a range of experiences of anxiety that affect condom use differently. While some individuals may experience excessive worry [121], leading to vigilance about condom use, others may experience impulsivity [122] that could lead to disregard for condom use. If at the individual level feelings of anxiety encourage or discourage condom use differently for different men, at the population level there may be no consistent observable relationship between general symptoms of anxiety and

condom use. Future studies should seek to understand how different anxious tendencies (e.g. worry-type vs. impulsive-type) relate to condom use.

Men in this study experienced substantial changes in their anxiety and depression symptoms. Substantial fluctuations in symptoms of anxiety and depression have been frequently observed, particularly among adolescents and young adults [123-125], and may be dependent upon the extent to which a person's anxiety and depression is related to genetic heritability rather than environmental influences [125]. Further research is needed to determine the extent to which sexual risk behaviors are associated with enduring traits of anxiety or depression as opposed to shorter-term states of anxiety or depression which may be highly contextually influenced. To further elucidate these relationships, event-level data such as ecological momentary assessment (EMA) data will be needed [126]. No such study has been undertaken in sub-Saharan Africa to our knowledge. Future studies employing event-level data should include a focus on the relationship between anxiety and partner concurrency, as there has been an overwhelming focus on depression in this line of research to date.

Limitations

There are important limitations to this study. Respondents' willingness to report sexual risk behaviors may have been associated with the social acceptability of such an acknowledgment. In addition, reports of sexual risk behaviors were retrospective, and thus recall bias may be an issue. The coding of the condom use and concurrency variables were designed to minimize the influence of recall bias, as discussed in the Methods. The HSCL-25 scale which was used to measure anxiety and depression was developed in a different cultural context than the study setting, though the scale version used has been previously validated in Tanzania [86, 87]. Further, the two time points as measured a year apart do not allow us to establish whether affective manifestations of anxiety and depression directly precede decisions to engage in risky sexual behaviors. Event-level data is needed to establish a precise temporal

relationship between anxiety and depression and sexual risk [126]. Within the limitations of the data available, the hypotheses as tested allow us to establish that changes in anxiety and depression are associated with sexual behaviors in this population.

Future directions

The results of this study indicate the need to address anxiety and depression among young men in HIV prevention efforts. Previous HIV prevention trials for women have been more effective when they have also been able to improve mental health [127]. While there are promising interventions to address depression in this context [128, 129], we need evidence-based interventions for anxiety in low resource settings. Promising models of mental health promotion which may be scalable in this setting include training nurses to implement mental health screening and treatment [129, 130], or training lay people to screen for common mental disorders and make referrals to counseling [131-133]. To be able to target such interventions, we need to understand which men are most at risk for anxiety and depression. More population-based research is needed in sub-Saharan Africa, but the few studies from this context indicate that depression may be associated with age [134, 135], marital status [134, 136, 137], education [136, 138], employment and income [135, 136, 138], and gender [134, 136]. Though studies have observed a higher risk of depression among women, the substantial levels of clinically significant symptoms of anxiety and depression among men in this study should not be discounted. Research specific to men will be needed as the determinants of anxiety and depression are likely to be different among men than among women [134, 136].

Conclusion

This study contributes to our understanding of the association between mental health and sexual risk behaviors among young men in an African urban setting. The results indicate that changes in anxiety and

depression were associated with both condom use and concurrency, but that anxiety may only independently affect concurrency and not condom use. As we found clinically significant symptoms of anxiety and depression among one out of five men in this setting, efforts to screen and provide treatment for depression and anxiety disorders are indicated as a potentially important component of primary HIV prevention in this setting. The results further indicate the development of effective HIV prevention interventions targeting young men living with anxiety and depression.

CHAPTER 5: PAPER 2

MODERATION BY OBSERVED AND PERCEIVED BEHAVIORAL NORMS OF THE RELATIONSHIP BETWEEN MENTAL HEALTH AND SEXUAL RISK AMONG YOUNG MEN LIVING IN DAR ES SALAAM, TANZANIA

5.1 BACKGROUND

There are 4 million young people ages 15-24 living with HIV [102], 85% of whom live in sub-Saharan Africa [103]. AIDS-related deaths among youth rose by 50% between 2005 and 2012 and adolescents and young adults account for a growing proportion of African populations [103], making the need to target and engage youth in HIV prevention increasingly important. In Tanzania specifically, 40 percent of new infections occur among 16-24 year olds [1]. Young men are important targets in HIV prevention in this context as gender norms position them to control the terms and conditions of sexual relationships [32], and encourage them to engage in high risk sexual behaviors including inconsistent condom use and sexual partner concurrency [1, 33-36]. Half of sexually active Tanzanian youth ages 15-24 did not use a condom at last intercourse in 2010, and nearly one-third reported concurrent partners [4].

HIV risk in eastern and southern Africa has been observed to cluster in informal urban settlements [139-141]. The majority of urban residents in southern and eastern Africa live in these settlements, informally known as slums [22]. The populations of these settlements are growing due to high levels with rapid urbanization. In Dar es Salaam, Tanzania's commercial capital, the current population of 4.4 million [19] is growing at an annual rate of 4.3% [142]. The city's growing population has led to a high demand for infrastructure which the government has been unable to meet, and as a result an estimated 70% of the city's population lives in informal settlements [22]. People living in these

settlements lack access to sufficient housing and basic services such as water and sanitation [142]. The prevalence of these living conditions is also explained by the high levels of poverty [143] and unemployment (21.5%) in the city [144]. Residence in contexts like these settlements is linked to HIV risk through a number of mechanisms. Both the state of poverty itself and the context of disadvantage in impoverished neighborhoods promote sexual risk behaviors [145-148]. As there are often poor education and employment options for youth in these settings [149, 150], youth often lack hope and positive orientation to the future [151], which is in turn linked to risk behavior [152, 153]. Neighborhood physical disorder also contributes to psychological distress [154] by providing a constant reminder of one's status in poverty, and can cause the individual to feel trapped in their current state [155]. The living environment can shape mental health through other stressors, such as violence, poor housing, noise, and crowding [156, 157]. These same stressors can lead to substance use [148, 158]. Both poor mental health and substance use can in turn shape sexual risk [145, 159].

An impoverished living context has also been associated with riskier norms related to sexual risk behavior. Communities have distinct social norms [160, 161], and the social isolation of impoverished neighborhoods can create a context in which distinct norms emerge and sustain themselves [155, 162]. Neighborhood disorder is also associated with the perceived prevalence of sexual risk behaviors [163]. The potential clustering of risky social norms is of concern for HIV prevention as norms can affect individuals' perceptions of acceptable behavior, and are particularly influential for youth who are more strongly influenced by the attitudes and behaviors of their peers than older adults [164]. Normative influence may take the form of active peer pressure [165], leading to perceptions of what actions are considered acceptable or unacceptable to peers known as *injunctive norms* [166]. Influence can also occur through less direct social learning processes [167, 168] whereby peers both transmit and reinforce norms [169], shaping individual perceptions of what peers are actually doing, known as *descriptive norms* [166].

In disadvantaged contexts, youth are exposed to multiple susceptibilities including normative risk behaviors and poor mental health. It is important to understand if these coexisting susceptibilities simply add to one another or compound in shaping young men's predisposition to sexual risk behaviors. Knowledge of such a compounding (or interaction) effect would indicate the need to address these susceptibilities in tandem and not in separate, targeted programs. Because of previous evidence from the study population of the relationship between anxiety, depression, and sexual risk [30], and preliminary evidence of peer normative influence on sexual risk behaviors in this population [170], we have chosen to focus on mental health and social norms to assess the extent to which these susceptibilities act together to shape sexual risk. In a previous study with the same population of young men living in Dar es Salaam, we found that changes in depression over a one-year period were independently associated with condom use and concurrency, and anxiety was independently associated with concurrency (see Chapter 4: Paper 1). We also previously found a significant clustering of condom use, partner concurrency, and attitudes toward these behaviors within subgroups of the study population (i.e. a significant proportion of the variance in these behaviors was attributable to group membership) [170]. Qualitative evidence from the study population further indicates normative influence on men's sexual behaviors, indicating that men pressure and encourage each other to engage in sexual risk behaviors [28].

Behavioral norms and mental health interact to shape drinking behaviors among youth in the US [171], but there are no studies to our knowledge assessing a similar relationship for sexual behaviors. To address this gap, we aim to understand if social norms moderate the relationship between mental health and sexual risk. We hypothesize that higher levels of risk behaviors among peers and perceptions of riskier norms among peers will serve to magnify this individual-level risk. In other words, we theorize that men with higher levels of anxiety or depression may have a higher inclination toward risk behaviors, and the influence of peer norms may increase the likelihood that this inclination manifests in actual risk

behaviors. Evidence of such an interaction between mental health and peer norms would indicate that there may be something social or learned about sexual risk as a response to poor mental health.

Further, we aim to gain specific understanding of the role of different types of social norms in men's sexual behaviors, and do so by additionally assessing the direct effect of observed peer behaviors and perceived behavioral norms on men's sexual behaviors. The results of this study offer implications for future interventions aiming to reduce HIV risk among young men living in urban informal settlements in east Africa.

5.2 METHODS

Study context

This study was conducted in the context of an ongoing HIV prevention trial, *A Multilevel Intervention to Reduce HIV Risk Among Networks of Men in Tanzania* (PI: Suzanne Maman; 1R01MH098690-01), a cluster randomized trial of a microfinance and health leadership intervention to prevent sexually transmitted infections and intimate partner violence [107]. The setting and design of this trial have been previously described in detail [107]. The study is taking place in the country's commercial capital, Dar es Salaam, where 7% of the population is living with HIV [2].

For this trial, we identified social networks of young men occupying designated venues known as "camps" in Dar es Salaam where men socialize and engage in small scale enterprise [28]. Participants in the present study are 1113 sexually active men who are members of 59 of these camps. Camps are stable social units; those included in the trial have been in existence for an average of eight years. Men typically belong to only one camp and pay membership fees to belong to that camp [28]. Camps are made up of youth who frequent the venue for its supportive social environment [28]. Most men in the camps are not formally employed and spend several hours each day at their camp [28]. These camps

provide unique access to social networks of high risk young men who are otherwise difficult to reach, as they are largely neither in school nor formally employed [28].

Sampling and data collection

We identified camps for inclusion in the trial in four wards (which are equivalent to U.S. census tracts) of Dar es Salaam (Manzese, Tandale, Mwananyamala, and Mabibo) using an adaptation of PLACE (Priorities for Local AIDS Control Efforts) methodology, a rapid assessment designed to locate venues where people meet new sexual partners through community informant and camp verification interviews [108]. To be eligible for inclusion in the trial, camps had to meet a number of eligibility requirements including having between 20 and 80 members, having been in existence for at least one year prior to the baseline assessment, and reporting no violent incidents during which a weapon was used within the past 6 months. A total of 303 camps were verified, of which 98 camps did not meet the trial's inclusion criteria. Of the 205 eligible camps identified, 60 camps were randomly selected for inclusion in the trial.

All members of camps selected in to the trial were preliminarily eligible for inclusion in the study. Following random selection, camp leaders were given a camp roster to fill with the names and basic information about each camp member. 1581 men were identified as camp members and assessed for eligibility. To be eligible for participation in the trial at baseline, participants had to: 1) be a registered camp member for at least three months; 2) plan on residing in Dar es Salaam for the next 30 months; 3) be 15 years or older; 4) visit the camp at least once per week; and 5) be willing to provide contact information for themselves and two family members or friends. Based on these criteria, 86 men (5.4%) were ineligible, and 25 (1.6%) refused to participate. We contacted but were unable to schedule appointments with 141 men (8.9%) and were unable to contact 71 individuals after three attempts (4.5%). A total of 1,258 men completed the baseline behavioral assessment. Soon after baseline data collection, camp members from one camp (n=9) requested to be removed from the study because their

leader falsified information regarding the camp's eligibility. This camp was removed, resulting in a final baseline sample of 1,249 men within 59 camp networks. 978 men in the 59 camps completed the follow-up assessment for 78% retention.

Measures

Both sexual behavior variables of condom use and concurrency were measured through self-report. An ordered-categorical condom use variable was calculated from a self-report of condom use over the 3 most recent sexual partners (number of sex acts over the most recent month of the relationship, and number of times condoms used for each partner). Using the proportion of reported sex acts where condoms were used (expressed as a percent, participants were assigned to one of three categories: "never use" (0% use), "some use" (greater than 0%, less than 100%), or "always use" (100%). Because of the possibility of some degree of recall bias over the course of the three most recent relationships, use of a continuous variable of condom use is not indicated as each unit increase would not necessarily indicate an important difference in condom use. Dichotomizing condom use, however, is not recommended by Noar et al. [83], thus use of a three-level categorical condom use variable preserves information in differences in use that can be reliably self-reported while reducing measurement error due to recall bias. Sexual concurrency was evaluated by self-report of any overlapping sexual partnerships for an individual's past 3 partners. Participants were asked to enumerate current and past sexual relationships and to report if they had sex with anyone else during any of these partnerships. Participants reporting any instance of simultaneous sexual relationships either currently or in the past 12 months were coded as displaying concurrency. This measure was developed following best practices recently recommended by USAID [84].

Four types of behavioral norms were measured for both condom use and concurrency: friends' reported behaviors, perceived descriptive norms, perceived injunctive norms, and reported friend

encouragement of the behavior. Men were asked to name their three closest friends in their camp by selecting names from a list of all camp members. The name of each nominated friend was associated with a unique identifier which was used to link this nomination record to the friend's reported behavior according to their own completed questionnaire. Taking the reported behavior of all three friends for each individual, we created an average percent condom use and a percent of friends reporting concurrency measure for each participant. To assess perceived descriptive norms, for condom use men were asked for each of these three closest friends, *"Do you think Friend X uses condoms all the time?"* For injunctive norms men were asked *"Do you think Friend X thinks that he should be using condoms all the time?"* Finally, to assess friends' encouragement of behaviors men were asked *"Has Friend X encouraged you to use condoms all the time?"* Men were asked analogous questions for partner concurrency and provided yes/no answers. We created a measure of the proportion of friends for which the respondent answered "yes" for each item.

Symptoms of anxiety and depression were measured using the Hopkins Symptom Checklist-25 (HSCL-25) [85], specifically a version of the scale previously translated into Kiswahili and tested in Tanzania [86]. This measure inventories symptoms of anxiety and depression in 25 items (10 related to anxiety, 15 to depression) rated on a 4-point Likert-type scale. The scale has been previously validated in Tanzania [86, 87]. Anxiety scores were calculated by taking the mean of the 10 anxiety-related items in the HSCL-25. In the sample the anxiety subscale showed good internal consistency at baseline (Cronbach's alpha = 0.94). Depression scores were calculated by taking the mean of the 15 depression-related items in the HSCL-25. At baseline the depression subscale also showed good internal consistency (a = 0.91).

Covariates included in all analyses include age, education level, economic status, marital status, and treatment condition. Age was calculated based on reported date of birth. In cases where birthdate was not reported, the participant's reported age in years was used. Participants reported the highest

level of education they had completed based on eight possible categories (no education, Standard 4 or less, Standard 5-7, Form 1, Form 2, Form 3, Form 4, Greater than Form 4). For analysis, education responses were collapsed into three categories: primary school or less (responses: no education, Standard 4 or less, Standard 5-7); some secondary school (responses: Form 1, Form 2, Form 3); or secondary school completed or greater (responses: Form 4, Greater than Form 4). Socioeconomic status (SES) was evaluated through an asset index, the Filmer Pritchett Wealth Index [91]. Participants were asked to indicate which of 10 possible assets they owned (e.g. cellphone, television) [92], and a composite score was created by weighting each asset by its loading on the first component in a principle components analysis and then placing individuals on a continuous scale of relative wealth [91]. The composite score for each participant was categorized into terciles based on the entire sample of men and women in our baseline dataset (the lowest 33% of participants were classified as “lowest SES”, the highest 33% were classified as “highest SES” and the remainder were classified as “middle SES”). Marital status was evaluated through a single yes/no item in which men were asked if they had ever been married. Finally, as the intervention being evaluated was designed to affect condom use and sexual partner concurrency, treatment condition (treatment or control) was included as a covariate to account for this design effect in all analyses.

Analysis

All statistical analyses were conducted in SAS v 9.4 and used a 2-sided significance level of 0.05. First, we described demographic characteristics of the participants and levels of variables of interest at baseline and at the follow-up. To address missing data from the behavioral survey (primarily due to attrition), we applied sequential multiple imputation using the fully conditional specification in *proc MI*. Forty imputations were created using a linear regression specification for continuous variables and a logistic regression specification for categorical variables. To account for missing network ties in the quadratic

assignment procedure discussed below, we conducted imputation by reconstruction as recommended by Huisman [97]. Specifically, we used random imputation of ties proportional to the observed network density (i.e., the probability of a tie is equal to the observed density of each network), as described by Huisman as an extension of Stork and Richard's method of reconstruction [97].

In a previous study we found that that within-person change in anxiety and depression between baseline and the follow-up assessment predicted follow-up risk behavior controlling for baseline risk behavior (see Chapter 4: Paper 1). In the present study we hypothesized that within-person change in behavioral norms would predict follow-up risk behavior controlling for baseline risk behavior, and that change in norms would moderate the relationship between changes in anxiety and depression, and sexual risk. To account for dependence due to clustering within camps, we fit multilevel models with a generalized link function. All models were fit using *proc glimmix* with quadrature estimation (using 15 quadrature points), random intercepts, and logit and cumulative logit link functions (for dichotomous concurrency, and three-level condom use, respectively). For all models the dependent variable was sexual risk (condom use or concurrency) measured at the follow-up, controlling for baseline sexual risk and the covariates listed above. The primary predictors were change in each behavioral norm score, change in anxiety or depression (baseline score subtracted from follow-up score), and their interaction.

Anxiety and depression are highly comorbid, and this was observed at the symptom-level in our sample (the correlation between symptoms of anxiety and depression was 0.76 at baseline and 0.74 at the follow-up). We were concerned that collinearity between measurements of their symptoms would limit the ability to interpret the independent effects of anxiety and depression when estimated simultaneously. For this reason, we tested three models for each combination of the four social norm moderators and two sexual behavior dependent variables (for a total of 24 models): 1) inclusion of change in anxiety symptoms only; 2) change in depression symptoms only; and 3) change in both anxiety and depression symptoms. For each model, we assessed the interaction between mental health and

peer norm change scores. Where these interaction terms were significant, we probed each significant interaction found by modeling the focal effect at the mean, one standard deviation above the mean, and one standard deviation below the mean of the moderator variable score [99].

For models including friend-reported behaviors as a predictor, to adjust standard errors due to the dependence of observations we included controls for subgroup clustering within each camp. As the same person could be nominated by multiple individuals as a friend, friendship cliques within the camps could lead to unobserved dependence within the data. To identify clique subgroups, we created a distance matrix for each camp where the cell values were the number of steps between each dyad. With each of these matrices we performed a principal components analysis to detect structurally significant subgroups within the camp, calculated the factor loading of each individual on each of the principal components, and included these factor loading terms in the models as a control [100].

In a separate modeling approach to further assess the role of peer influence on condom use and concurrency in men's full camp networks (as opposed to among men's closest friends), we tested network correlations for condom use and concurrency, controlling for factors associated with friendship formation and the aforementioned demographic and treatment condition control variables. We tested these correlations within each of the 59 camp networks using a Quadratic Assignment Procedure (QAP). QAP is a non-parametric procedure for significance testing which is used to infer social influence by relating measures of structural similarity (in this case, structural similarity is defined by the existence of friendship tie) between two network members to a measure of their similarity on variables of interest [77]. QAP produces an empirical distribution of the model coefficients through random permutation of model matrices against which to compare parameter estimates for hypothesis testing [77]. Given a significance level of 0.05, an observed parameter is determined to be statistically significant if it is greater than 95 percent of the values in the empirical distribution based on 2000 iterations [77].

Ethical Review

The study was approved by the ethical review committees at the University of North Carolina at Chapel Hill and Muhimbili University of Health and Allied Sciences in Dar es Salaam, Tanzania. Individual written informed consent was obtained from all study participants.

5.3 RESULTS

1249 men were interviewed at baseline, of whom 1113 (89%) reported being sexually active. 871 of these 1113 men (78%) participated at the follow-up. Men who did not participate at the follow-up did not significantly differ in their risk behavior from men who did (condom use: $\chi^2 = 0.31$ $p = 0.58$; concurrency: OR = 0.94 $p = 0.75$). The 1113 men who reported being sexually active at baseline were included in the analyses presented below.

Participant characteristics

Sexually active men interviewed at baseline had an average age of 27 years (range: 15 to 59). Over half had a primary school education or less (59%), nearly a third had graduated from secondary school (31%), and the remaining 11% had some secondary school but had not graduated. A quarter of the men had ever been married (25%) and 38% had children.

Table 9. Baseline Participant Characteristics (n=1113)^a

	N(%) or Mean \pm SD
Age (y) ^{***}	26.8 \pm 7.1
Currently in school	97 (8.7%)
Education level (ref = less than primary school completed) ^{***}	
Primary school or less	652 (58.7%)
Some secondary school	116 (10.5%)
Secondary school completed or greater	342 (30.8%)
Socioeconomic status	
Lowest	291 (26.2%)
Middle	435 (39.1%)
Highest	386 (34.7%)
Ever married	277 (25.0%)
Has children	423 (38.0%)

Cross-sectional description and change in key variables

Men had an average score of 1.4 (range 1 to 4 with higher scores indicating more severe symptoms) for both anxiety and depression symptoms at both baseline and at the follow-up assessment (Table 10). Though mean change in depression and anxiety scores were both close to zero, there was substantial variation in change scores (-0.03 ± 0.76 for depression and -0.03 ± 0.72 for anxiety). At baseline 21% reported clinically significant symptoms of depression and 19% reported clinically significant symptoms of anxiety based on common clinic cutoffs (score ≥ 1.75 [90]). At the follow-up, 20% and 16% of respondents met the criteria for depression and anxiety, respectively. The within-person correlation between baseline and follow-up symptoms was 0.08 for anxiety and 0.13 for depression. The correlation between symptoms of anxiety and depression was high at both time points: 0.76 at baseline and 0.74 at the follow-up. Furthermore, the correlation between within-person change in anxiety and depression symptoms was 0.73.

At the sample level, there were relatively similar levels of condom use and concurrency across the two time points. About half of men reported never using condoms at both baseline and the follow-up (53% and 52%, respectively). More men reported always using condoms at baseline than at the follow-up (33% and 26%, respectively). 14% of men reported sometimes using condoms at baseline, and this proportion increased to 22% at the follow-up. The within-person correlation between baseline and follow-up percent condom use was 0.21. Many more men reported concurrency at the follow-up (262, 32%) than at baseline (193, 20%). The within-person correlation between baseline and follow-up concurrency was 0.16.

By friends' own self report, on average, men's three closest friends used condoms 43% of the time at baseline and 38% of the time at the follow-up. Condom use by men's friends decreased by an average of 6% by the follow-up. At baseline, on average, 21% of men's friends reported concurrency, and 30% did so at the follow-up for an average increase of 10%. In comparison, at baseline men perceived on average that 42% of their friends used condoms all the time, and that 24% of their friends had concurrent sexual partners (perceived descriptive norms). They also perceived that 59% of their friends thought that they should use condoms all the time and that only 18% would approve of them having concurrent sexual partners (perceived injunctive norms). Participants reported on average that 49% of friends had encouraged them to use condoms all the time, while 39% had discouraged them from having concurrent sexual partners. Each of these perceptions increased by a factor of 8% to 22% by the follow-up, with the greatest increase occurring in injunctive condom use norms.

Table 10. Cross-sectional description of key variables^a

	Baseline	Follow-up	Within-person change
<i>Internalizing symptoms</i>			
Depression score	1.43 ± 0.57	1.42 ± 0.56	-0.03 ± 0.76
Anxiety score	1.38 ± 0.51	1.36 ± 0.53	-0.03 ± 0.72
Depression (score ≥ 1.75)	237 (21.3%)	174 (20.0%)	--
Anxiety (score ≥ 1.75)	206 (18.5%)	141 (16.2%)	--
Both depression and anxiety (both scores ≥ 1.75)	164 (14.7%)	101 (11.6%)	--
<i>Sexual risk</i>			
Condom use			
Never	491 (52.7%)	408 (51.6%)	--
Sometimes	133 (14.3%)	176 (22.3%)	--
Always	308 (33.1%)	207 (26.2%)	--
Concurrency	193 (20.2%)	262 (32.1%)	--
<i>Observed peer norms</i>			
Condom use	0.43 ± 0.37	0.38 ± 0.33	-0.06 ± 0.50
Concurrency	0.21 ± 0.30	0.30 ± 0.34	0.10 ± 0.44
<i>Perceived peer norms</i>			
Descriptive condom use	0.42 ± 0.46	0.54 ± 0.42	0.13 ± 0.57
Injunctive condom use	0.59 ± 0.46	0.81 ± 0.32	0.22 ± 0.52
Condom use encouraged	0.49 ± 0.44	0.66 ± 0.39	0.17 ± 0.55
Descriptive concurrency	0.24 ± 0.38	0.36 ± 0.39	0.11 ± 0.51
Injunctive concurrency	0.18 ± 0.33	0.26 ± 0.38	0.08 ± 0.50
Concurrency discouraged	0.39 ± 0.43	0.48 ± 0.41	0.09 ± 0.57

^aData are expressed as No. (%) or Mean ± SD

Association between observed and perceived predictors

In comparing friends' reported behaviors and men's perceptions of behavioral norms among their friends (Table 11), none of the correlations surpassed an absolute value of 0.04, and none of the correlations were statistically significant. Friends' own reports of their condom use and concurrency

were not associated with men’s perceptions of their friends’ behaviors, their approval of these behaviors, or reports of their friends’ encouragement of these behaviors.

Table 11. Baseline correlations between observed and perceived norms

Observed measure	Perceived measure		
	<i>Perceived descriptive norm</i>	<i>Perceived injunctive norm</i>	<i>Behavior encouraged</i>
Condom use	-0.002	0.037	0.038
Concurrency	0.000	-0.013	-0.034

Peer similarity in behaviors, anxiety, and depression

The results of the QAP analyses are presented in Figure 4 below, presented as box plots of the distribution of the individual results for each of the 59 camps. Overall, there was little evidence for peer similarity in concurrency or condom use at the camp level. On average across all camps, friends had 0.92 times the odds of having the same concurrency as non-friends (range: 0.43, 2.38; $\beta(\log \text{ odds}) = -0.08$), but the estimated association was only significant at $\alpha = .05$ level for 9 (15%) of camps. Friends had 0.07 greater similarity in percent condom use than non-friends (range: -0.10, 0.40), but the estimated association was only significant for 7 (12%) of camps.

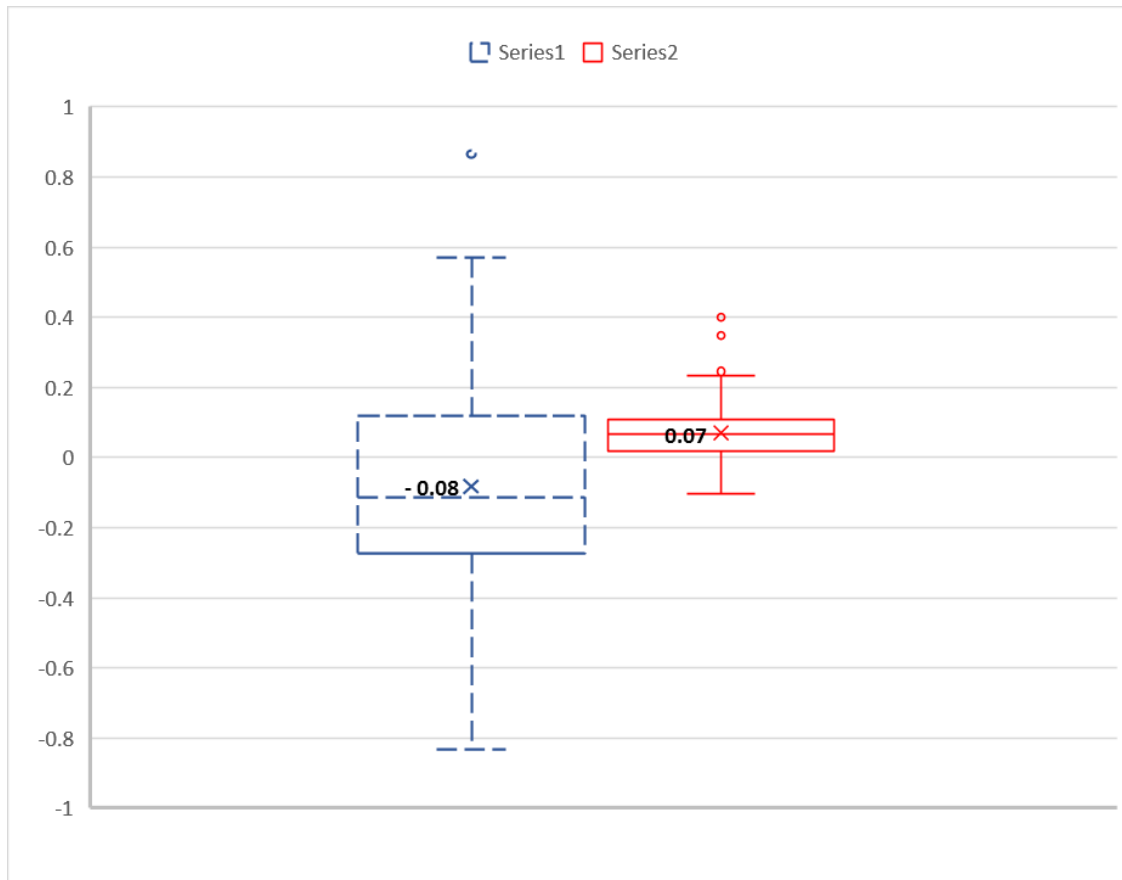


Figure 4. Box plot distributions of QAP correlations by camp

Condom use models

In assessing moderation by condom use norms of the relationship between mental health and men’s own condom use, we found that change in perceived descriptive condom use was significantly associated with men’s condom use (aOR 1.63; 95% CI: 1.22, 2.26). Changes in perceived descriptive condom use also significantly interacted with changes in anxiety symptoms in association with condom use (aOR 1.95; 95% CI: 1.10, 3.47). Changes in perceived injunctive norms around condom use were not significantly related to condom use, nor did they significantly interact with anxiety or depression change. Changes in friend encouragement of condom use were significantly associated with men’s condom use (aOR 1.54; 95% CI: 1.15, 2.05). Changes in friends’ self-reported condom use were not significantly associated with men’s own condom use (aOR 0.81; 95% CI: 0.55, 1.19) and did not significantly interact

with anxiety or depression change. The estimates presented above are taken from the third series of models which included both changes in anxiety and depression as predictors, with very similar estimates seen in this series of models as compared to series 1 (anxiety predictor only) or series 2 (depression predictor only). Significant interactions are presented in Figure 5 and discussed below.

Table 12. Condom use peer norm interaction model results

	Moderator			
	Descriptive condom use	Injunctive condom use	Encourage condom use	Observed condom use
	aOR (95%CI)	aOR (95%CI)	aOR (95%CI)	aOR (95%CI)
1. Anxiety and peer condom use				
<i>Main effect model</i>				
ΔAnxiety	0.87 (0.71, 1.07)	0.84 (0.67, 1.03) [†]	0.86 (0.70, 1.06)	0.83 (0.65, 1.06)
ΔMod	1.66 (1.22, 2.26)**	1.17 (0.87, 1.59)	1.56 (1.17, 2.07)**	0.81 (0.56, 1.18)
<i>Interaction model</i>				
ΔAnxiety	0.82 (0.66, 1.01)	0.78 (0.61, 0.99)*	0.81 (0.65, 1.01)	0.84 (0.65, 1.08)
ΔMod	1.62 (1.19, 2.20)**	1.15 (0.85, 1.56)	1.53 (1.15, 2.05)**	0.81 (0.55, 1.18)
ΔAnxiety*ΔMod	1.56 (1.08, 2.24)*	1.30 (0.86, 1.95)	1.40 (0.98, 2.01) [†]	1.10 (0.61, 1.97)
2. Depression and peer condom use				
<i>Main effect model</i>				
ΔDepression	0.77 (0.63, 0.94)*	0.74 (0.60, 0.90)**	0.76 (0.62, 0.92)*	0.73 (0.57, 0.94)*
ΔMod	1.61 (1.19, 2.19)**	1.12 (0.83, 1.52)	1.52 (1.14, 2.03)**	0.82 (0.56, 1.19)
<i>Interaction model</i>				
ΔDepression	0.74 (0.60, 0.91)**	0.69 (0.55, 0.87)**	0.74 (0.60, 0.91)**	0.74 (0.57, 0.95)*
ΔMod	1.60 (1.17, 2.17)**	1.11 (0.82, 1.51)	1.51 (1.13, 2.02)**	0.81 (0.56, 1.19)
ΔDepression*ΔMod	1.25 (0.90, 1.74)	1.29 (0.88, 1.90)	1.14 (0.83, 1.57)	1.06 (0.62, 1.82)
3. Anxiety, depression, and peer condom use				
<i>Main effect model</i>				
ΔAnxiety	1.14 (0.86, 1.51)	1.04 (0.76, 1.47)	1.14 (0.86, 1.51)	1.09 (0.79, 1.51)
ΔDepression	0.71 (0.54, 0.93)*	0.69 (0.53, 0.91)**	0.70 (0.53, 0.91)*	0.69 (0.50, 0.96)*
ΔMod	1.63 (1.20, 2.22)**	1.14 (0.84, 1.55)	1.54 (1.15, 2.05)**	0.81 (0.55, 1.19)
<i>Interaction model</i>				
ΔAnxiety	1.07 (0.79, 1.44)	1.11 (0.83, 1.43)	1.04 (0.77, 1.40)	1.09 (0.78, 1.54)
ΔDepression	0.71 (0.53, 0.94)*	0.67 (0.49, 0.91)**	0.72 (0.54, 0.95)*	0.69 (0.50, 0.97)*
ΔMod	1.58 (1.16, 2.15)**	1.11 (0.82, 1.52)	1.52 (1.14, 2.04)**	0.81 (0.55, 1.18)
ΔAnxiety *ΔMod	1.95 (1.10, 3.47)*	1.25 (0.71, 2.20)	1.75 (1.01, 3.02)*	1.03 (0.45, 2.37)
ΔDepression*ΔMod	0.79 (0.46, 1.33)	1.10 (0.64, 1.89)	0.78 (0.48, 1.26)	1.05 (0.48, 2.26)

† p<0.1; *p<0.05; **p<0.01; ***p<0.001;

Note: All models include controls for condition, age, education level, SES, and ever having been married.

Looking specifically at the interaction between anxiety symptoms and descriptive condom use in association with men's condom use, we present plots of the simple intercepts and slopes of the association between anxiety change and condom use, at the mean, at one standard deviation above, and at one standard deviation below the mean of each condom use norm change score (Figure 5). Here we present simple slopes as beta coefficients based upon the estimates from model series 1 (anxiety predictor only) for the sake of the interpretability of the observed interaction.

At the mean level of change in perceived descriptive condom use, men with greater increases in anxiety symptoms reported lower levels of condom use (simple slope = -0.20, $p = 0.035$). This association was amplified with decreasing/worsening perceived descriptive norms for condom use (simple slope at one standard deviation below the mean = -0.44, $p = 0.004$), and attenuated by increasing/improving perceived descriptive norms for condom use (simple slope at one standard deviation above the mean = 0.03, $p = 0.776$).

Similarly, at the mean level of change in condom use encouragement, men with greater increases in anxiety symptoms reported lower levels of condom use (simple slope = -0.21, $p = 0.030$). This association was amplified with decreasing encouragement of condom use (simple slope at one standard deviation below the mean = -0.39, $p = 0.009$), and attenuated by increasing encouragement of condom use (simple slope at one standard deviation above the mean = -0.03, $p = 0.761$).

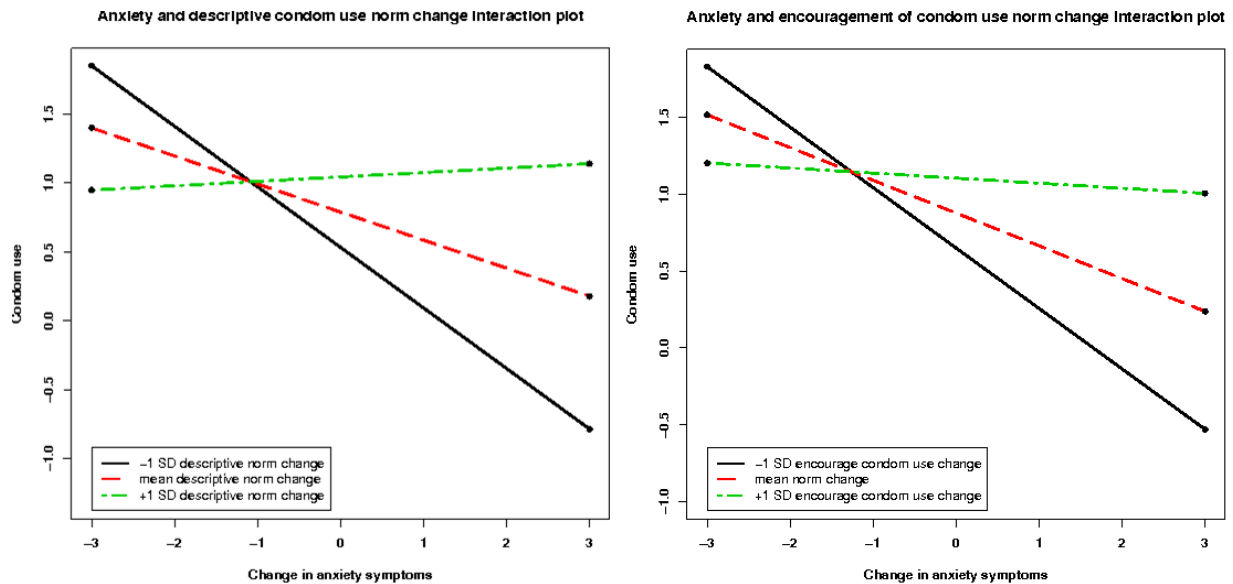


Figure 5. Interaction plots for condom use models

Concurrency models

In testing the hypotheses regarding moderation by concurrency norms of the relationship between mental health and partner concurrency, changes in perceived descriptive concurrency norms (aOR 1.42; 95% CI: 1.02, 2.00) and injunctive concurrency norms (aOR 1.50; 95% CI: 1.08, 2.10) were significantly associated with men’s concurrency. However, changes in levels of concurrency discouragement and observed friend concurrency were not significantly associated with concurrency. None of these hypothesized moderators significantly interacted with either change in anxiety or depression in association with concurrency. The estimates presented above are taken from the third series of models which included both changes in anxiety and depression as predictors, with very similar estimates seen in this series of models as compared to series 1 (anxiety predictor only) or series 2 (depression predictor only).

Table 13. Concurrency peer norm interaction model results

	Moderator			
	Descriptive concurrency	Injunctive concurrency	Discourage concurrency	Observed concurrency
	aOR (95%CI)	aOR (95%CI)	aOR (95%CI)	aOR (95%CI)
1. Anxiety and peer concurrency				
<i>Main effect model</i>				
ΔAnxiety	1.58 (1.25, 2.00)***	1.59 (1.26, 2.01)***	1.57 (1.24, 1.99)***	1.59 (1.21, 2.10)**
ΔMod	1.43 (1.02, 2.00)*	1.53 (1.09, 2.13)*	0.81 (0.61, 1.08)	0.72 (0.44, 1.17)
<i>Interaction model</i>				
ΔAnxiety	1.67 (1.31, 2.14)***	1.63 (1.29, 2.07)***	1.56 (1.24, 1.97)***	1.59 (1.19, 2.12)**
ΔMod	1.49 (1.06, 2.11)*	1.58 (1.12, 2.22)**	0.80 (0.60, 1.06)	0.72 (0.44, 1.17)
ΔAnxiety*ΔMod	0.67 (0.43, 1.05)†	0.75 (0.47, 1.20)	1.19 (0.77, 1.83)	1.04 (0.53, 2.02)
2. Depression and peer concurrency				
<i>Main effect model</i>				
ΔDepression	1.54 (1.24, 1.91)***	1.53 (1.24, 1.90)***	1.53 (1.24, 1.90)***	1.57 (1.22, 2.02)***
ΔMod	1.42 (1.01, 2.00)*	1.48 (1.06, 2.07)*	0.80 (0.60, 1.07)	0.74 (0.46, 1.21)
<i>Interaction model</i>				
ΔDepression	1.62 (1.29, 2.02)***	1.57 (1.26, 1.96)***	1.53 (1.24, 1.90)***	1.54 (1.19, 1.99)**
ΔMod	1.48 (1.06, 2.08)*	1.54 (1.10, 2.16)*	0.79 (0.59, 1.05)	0.71 (0.44, 1.17)
ΔDepression*ΔMod	0.72 (0.47, 1.10)	0.74 (0.47, 1.16)	1.22 (0.84, 1.79)	1.30 (0.67, 2.50)
3. Anxiety, depression, and peer concurrency				
<i>Main effect model</i>				
ΔAnxiety	1.31 (0.94, 1.81)	1.33 (0.96, 1.85)	1.29 (0.93, 1.79)	1.31 (0.90, 1.91)
ΔDepression	1.29 (0.95, 1.74)	1.27 (0.94, 1.72)	1.29 (0.95, 1.75)	1.31 (0.93, 1.84)
ΔMod	1.42 (1.02, 2.00)*	1.50 (1.08, 2.10)*	0.82 (0.61, 1.09)	0.73 (0.45, 1.18)
<i>Interaction model</i>				
ΔAnxiety	1.36 (0.95, 1.95)	1.34 (0.95, 1.88)	1.28 (0.92, 1.78)	1.33 (0.90, 1.96)
ΔDepression	1.31 (0.95, 1.81)	1.30 (0.94, 1.78)	1.30 (0.96, 1.76)	1.28 (0.90, 1.81)
ΔMod	1.50 (1.06, 2.11)*	1.57 (1.12, 2.20)**	0.79 (0.60, 1.06)	0.71 (0.44, 1.17)
ΔAnxiety *ΔMod	0.73 (0.37, 1.47)	0.90 (0.46, 1.77)	1.05 (0.55, 2.03)	0.76 (0.29, 2.01)
ΔDepression*ΔMod	0.90 (0.46, 1.75)	0.79 (0.42, 1.51)	1.17 (0.66, 2.07)	1.54 (0.60, 3.95)

† p<0.1; *p<0.05; **p<0.01; ***p<0.001;

Note: All models include controls for condition, age, education level, SES, and ever having been married.

5.4 DISCUSSION

The results of this study indicate that changes in perceived norms of behaviors among men’s closest friends are associated with men’s own condom use and concurrency behaviors. Specifically, perceived descriptive norms were associated with both condom use and concurrency, perceived injunctive norms were associated with concurrency, and direct encouragement was associated with condom use.

Changes in perceived condom use norms (descriptive norms and reported encouragement) also interacted with changes in anxiety symptoms to shape condom use. Perceived norms and the observed behaviors of men's closest friends were not significantly correlated. Changes in the observed behaviors of men's closest friends were also not associated with men's own behaviors. Further, there was little evidence of significant observed similarity in these behaviors in men's larger camp friendship networks.

We found multiple significant associations between men's perceptions of behavioral norms among their closest friends and their own behaviors. Such perceptions can affect behavior as a normative behavior is seen as the "correct" or wise thing to do in a given social context [172]. People may also anticipate social acceptance or increase in social status as a result of assuming a normative behavior [173, 174]. Motivation to adhere to the norm may even increase when peers directly reinforce perceptions of anticipated social rewards e.g. through direct encouragement [175]. Among men's closest friends, we found that both perceived descriptive norms and friends' encouragement were associated with men's condom use, and descriptive and injunctive norms were associated with concurrency. While it appears that men's perceptions of their friends' adoption of behaviors (descriptive norms) are related to both condom use and concurrency, future studies should attempt to understand why direct encouragement may be related to condom use but not concurrency, and why perceptions of what behaviors friends find acceptable (injunctive norms) may be related to men's concurrency but not condom use.

We also found that descriptive condom use norms and encouragement to use condoms interacted with anxiety to shape condom use. This interaction between mental health and peer norms can be understood through the fact that peer influence not only acts to directly shape behavior but peers may serve as a reference groups which individuals look to in behavioral decision-making [68]. In this way, higher levels of risk behaviors and approval thereof among direct peers will serve to magnify individual-level risks, such as those posed by poor mental health. Our results echo previous findings

related to mental health, behavioral norms, and alcohol use. One study found that worse mental health in combination with risky peer drinking norms led to more negative outcomes related to drinking behavior [171]. Similarly, a study among college students found that perceived peer drinking norms moderated the association between social anxiety and alcohol use [176], and another study found a similar relationship for depressive symptoms [177]. Building upon this literature, our results provide novel evidence of the interaction between mental health and sexual behavior norms. As we only found interactions in the relationship between anxiety and condom use, future studies should seek to understand why perceived norms might not interact with depression to shape young men's sexual behaviors, and why norms related to concurrency may not magnify the relationship between mental health and concurrency as they seem to do for condom use.

While we found numerous associations between perceived norms and men's behavior, we found no support for the association between men's behavior and the self-reported behaviors of men's closest friends or their larger camp friendship networks. These results were surprising given previous studies which have found that individuals' sexual behaviors, including partner concurrency [58] and condom use [59-62], reflect their peers' behavior. Specifically, these studies found that youth exposed to higher levels of concurrency or lower levels of condom use among their peers were more likely to display concurrency or lower levels of condom use themselves. It is possible that men have other important friendships outside of their camps which may be more relevant to their own sexual behavior than camp friendships. However, the fact that men's perceptions of camp friends' behaviors *were* associated with their own behaviors gives precedence rather to the hypothesis that norms among these friend groups were salient to men's behavioral decision making, but men's perceptions of their friends' behaviors simply did not match their friends' actual behaviors.

To this point, we found no significant correlations between men's perceptions of their friends' behaviors and their friends' own self-reported behaviors, similar to previous findings in this population

with regard to perceptions of friends' HIV testing [178]. Such a finding is not entirely surprising, as individuals' perceptions of norms are related to observable peer behaviors, but these perceptions rarely match what peers are actually doing as perceptions of norms are filtered through each individual's unique position and perspective [179]. Previous research has shown that individuals tend to underestimate their peers' protective behaviors and overestimate their risky behaviors [180]. Other studies have observed a false consensus effect, observing a tendency to misperceive peer behavior in a direction that is consistent with their own behavior [181, 182]. Further, as people have limited opportunity to observe their friends' behaviors, they often take mental shortcuts and unconsciously extrapolate ideas of descriptive norms using availability heuristics, interpreting norms from observations and stored memories that are most readily available [183]. For example, a peer who has a second concurrent partner may draw more interest or attention than peers who have only one partner, making the examples of concurrency more cognitively available.

Taken together, these perceptual biases could explain the fact that men's perceived norms did not correlate with directly observed reports of friends' behaviors, and may explain the observed relationship between perceived norms and men's own behaviors. Though the change predictors included in our models indicate that within-individual changes in perceived norms were associated with men's behaviors, future research is needed to better determine the temporality in these relationships, i.e. to determine if changes in perceived norms precede changes in behaviors or vice versa. It is also possible that norms and these behaviors are mutually deterministic, that norms shape behaviors and perceived norms may in turn be revised to align more closely with men's own behaviors. A better understanding of these relationships is needed to inform norm change interventions, such as popular opinion leader interventions which aim to leverage the normative influence of key community members often used to target HIV risk behaviors [184-186].

Limitations

There are important limitations to this study. Respondents' willingness to report sexual risk behaviors may have been associated with the social acceptability of such an acknowledgment. In addition, reports of sexual risk behaviors were retrospective, and thus recall bias may be an issue. However, the coding of the condom use and concurrency variables was designed to minimize the influence of recall bias, as discussed in the Methods. The HSCL-25 scale which was used to measure anxiety and depression was developed in a different cultural context than the study setting, though the scale used has been previously validated in Tanzania [86, 87]. We were unable to represent all of the normative influences in men's lives as we did not capture information about the behaviors and norms of peers outside of the camps, thus the results of this study can only represent the normative context within camps.

Nevertheless, the relationships and associated norms captured in this study reflect an important peer group for men belonging to these camps. In nominating their closest friends, men were limited to three nominees which may have excluded other close friends who participants may consider to be just as close as those named. There was approximately 22% attrition in the analytic sample at the follow-up assessment. While loss to follow-up might be speculated to occur among men with the poorer mental health and more sexual risk, men who did not participate at the follow-up did not significantly differ in their risk behavior from men who did (condom use: $\chi^2 = 0.31$ $p = 0.58$; concurrency OR = 0.94 $p = 0.75$). Furthermore, the application of multiple imputation served to minimize the influence of any potential bias from loss to follow-up. Finally, with the present data we cannot say if a changes in norms and mental health preceded changes in men's sexual behaviors. It is possible that the observed association between changes in perceived norms and men's behaviors are the result of a false consensus effect, i.e. that men's perceptions of norms changed to match their own behaviors. Experimental research with successful manipulation of perceived norms is needed to better determine the temporal direction of a potential causal relationship between perceived norms and these behaviors. With the current analysis

we are able to assess the association of changes in mental health and social norms with men's behaviors at the follow-up controlling for their baseline behavior.

Implications for future research and intervention

Future studies should seek to understand why different perceived descriptive, injunctive, and encouragement norms are more closely related to condom use or concurrency, and why perceived behavioral norms would interact with anxiety but not depression to shape sexual risk behaviors. A better understanding of these relationships and potential mechanisms explaining them would help to understand how to target different types of norms for different behaviors to optimize HIV prevention interventions. Scientists should also seek to understand what shapes men's perceptions of their friends' behaviors if not their friends' actual behaviors. Such an understanding would help to identify other potential important psychosocial targets for behavioral interventions. Future HIV prevention interventions should consider the importance of targeting perceived social norms and mental health simultaneously, as our results indicate that these factors act together to shape sexual behavior. In norms-focused interventions, it will be important to consider how participants' mental health, specifically anxiety, could affect the success of the intervention. In programs aiming to promote mental health, interventionists should consider the additional importance of condom use and concurrency norms, and aim to target perceptions of risky norms to prevent risk behaviors. These measures will be particularly important among marginalized populations similar to the camps in the study, as men in these contexts may be exposed to multiple susceptibilities to risk behavior, including poor mental health and risky social norms.

Conclusion

In this study of sexual risk behaviors among young men living in Dar es Salaam, we found that perceived norms affected young men's behaviors, and that these norms interacted with anxiety to shape sexual risk. We further found that perceived norms may not reflect actual peer behaviors, and found no evidence of peer influence in comparing observed behaviors in among men's closest friends and in their larger friendship networks. The results of this study provide novel evidence of the interacting effects of poor mental health and risky perceived norms among a hard to reach population of marginalized young men in Dar es Salaam. As such susceptibilities are common in the many informal settlements throughout eastern and southern Africa, our findings provide important information for future norms-based and mental health promotion interventions targeting HIV prevention in this key population.

CHAPTER 6: AIM 3 RESULTS

Originally the analyses for Aims 2 and 3 were intended to be included in one paper, however the entire results of both Aims were deemed to be too much to include in a single publishable paper by the Chair and the Student. Thus, the second manuscript (Chapter 5) includes the results relating to Aim 2 only. I conducted the analyses for Aim 3 and found no significant associations between cohesion or centrality and men's behavior. Further, none of the hypothesized interactions were significant. Therefore, I have included these results in this abbreviated chapter that includes background, methods, results, and a brief discussion. There is no plan to publish these results.

6.1 BACKGROUND

85% of the 4 million young people ages 15-24 living with HIV are in sub-Saharan Africa [103]. AIDS-related deaths among youth rose by 50% between 2005 and 2012 and adolescents and young adults account for a growing proportion of African populations [103], making the need to target and engage youth in HIV prevention increasingly important. Condom use and sexual partner concurrency are important behavioral targets for HIV prevention among youth; half of sexually active Tanzanian youth ages 15-24 did not use a condom at last intercourse in 2010, and nearly one-third reported concurrent partners [4].

Anxiety and depression are important correlates of sexual risk [5, 6, 8-10, 104] and may influence risk through multiple mechanisms including substance use [10], maladaptive coping to deal with stress [47], and impaired decision making [48]. We need a better understanding of social resources which may serve to buffer the risk posed by poor mental health. Social support may play such a role;

Cohen's stress buffering theory indicates that social support can operate to intervene between the experience of stress (in this case, the experience of anxiety and/or depression) and maladaptive coping behaviors (such as sexual risk) by reducing the effect of the stressor or psychological processes which occur in response to the stressor [78]. Lazarus and Folkman's Transactional Model of Stress and Coping provides further support for social support's role in promoting positive rather than negative coping outcomes [79], again indicating network social support as a potential moderator between stress related to anxiety and depression and maladaptive coping outcomes (sexual risk behaviors). Lazarus and Folkman posited that social support buffers the relationship between stressors and health behaviors by acting upon coping efforts (actions and processes to deal with the effect of stress), including problem management and emotional regulation [79].

Through the mechanism of social support, social cohesion and greater social connections (centrality) may serve to reduce risk behaviors among people living with anxiety and depression. In her model of social network influence on health behaviors, Lisa Berkman postulates that macro-level network structure and an individual's connections within their networks will shape exposure to micro-level mechanisms, including social support [76]. Following this model, I posit that greater social cohesion and centrality increase opportunities for social support. While there is much interest and previous research on the health promoting effects of social support, a functional aspect of social relationships, little attention has been paid to the health impact of the structure of social relations. In this Aim, I assessed the role of network structure (cohesion) and position (centrality) as moderators of the relationship between mental health and sexual risk. To do this I assessed the following hypotheses:

Hypothesis 3a: *Young men's centrality within their camp social network will moderate the relationship between mental health and sexual risk behaviors such that the relationship will be weaker for men with higher centrality than for those with lower centrality.*

Hypothesis 3b: *Network social cohesion will moderate the relationship between mental health and sexual risk behaviors such that the relationship will be weaker for young men in camps with higher levels of social cohesion than for those in camps with lower levels of social cohesion.*

6.2 METHODS

Study context

This study was conducted in the context of an ongoing HIV prevention trial, *A Multilevel Intervention to Reduce HIV Risk Among Networks of Men in Tanzania* (PI: Suzanne Maman; 1R01MH098690-01), a cluster randomized trial of a microfinance and health leadership intervention to prevent sexually transmitted infections and intimate partner violence [107]. The setting and design of this trial have been previously described in detail [107]. The study is taking place in the country's commercial capital, Dar es Salaam, where 7% of the population is living with HIV [2]

For this trial, we identified social networks of young men occupying designated venues known as “camps” in Dar es Salaam where men socialize and engage in small scale enterprise [28]. Participants in the present study are 1113 sexually active men who are members of 59 of these camps. Camps are stable social units; those included in the trial have been in existence for an average of eight years. Men typically belong to only one camp and pay membership fees to belong to that camp [28]. Camps are made up of youth who frequent the venue for its supportive social environment [28]. Most men in the camps are not formally employed and spend several hours each day at their camp [28]. These camps provide unique access to social networks of high risk young men who are otherwise difficult to reach, as they are neither in school nor formally employed [28].

Sampling and data collection

We identified camps for inclusion in the trial in four wards (which are equivalent to U.S. census tracts) of Dar es Salaam (Manzese, Tandale, Mwananyamala, and Mabibo) using an adaptation of PLACE (Priorities for Local AIDS Control Efforts) methodology, a rapid assessment designed to locate venues where people meet new sexual partners through community informant and camp verification interviews [108]. To be eligible for inclusion in the trial, camps had to meet a number of eligibility requirements including having between 20 and 80 members, having been in existence for at least one year prior to the baseline assessment, and reporting no violent incidents during which a weapon was used within the past 6 months. A total of 303 camps were verified, of which 98 camps did not meet the parent study's inclusion criteria. Of the 205 eligible camps identified, 60 camps were randomly selected for inclusion in the study.

All members of camps selected in to the trial were preliminarily eligible for inclusion in the study. Following random selection, camp leaders were given a camp roster to fill with the names and basic information about each camp member. 1581 men were identified as members and assessed for eligibility. To be eligible for participation in the trial at baseline, participants had to: 1) be a registered camp member for at least three months; 2) plan on residing in Dar es Salaam for the next 30 months; 3) be 15 years or older; 4) visit the camp at least once per week; and 5) be willing to provide contact information for themselves and two family members or friends. Based on these criteria, 86 men (5.4%) were ineligible, and 25 (1.6%) refused to participate. We contacted but were unable to schedule appointments with 141 men (8.9%) and were unable to contact 71 individuals after three attempts (4.5%). A total of 1,258 men completed the baseline behavioral assessment. Soon after baseline data collection, camp members from one camp (n=9) requested to be removed from the study because their leader falsified information regarding the camp's eligibility. This camp was removed, resulting in a final

baseline sample of 1,249 men within 59 camp networks. 978 men in the 59 camps completed the follow-up assessment for 78% retention.

Measures

Both sexual behavior variables of condom use and concurrency were measured through self-report. An ordered-categorical condom use variable was calculated from a self-report of condom use over the 3 most recent sexual partners (number of sex acts over the most recent month of the relationship, and number of times condoms used for each partner). Using the proportion of reported sex acts where condoms were used (expressed as a percent, participants were assigned to one of three categories: “never use” (0% use), “some use” (greater than 0%, less than 100%), or “always use” (100%). Because of the possibility of some degree of recall bias over the course of the three most recent relationships, use of a continuous variable of condom use is not indicated as each unit increase would not necessarily indicate an important difference in condom use. Dichotomizing condom use, however, is not recommended by Noar et al. [83], thus use of a three-level categorical condom use variable preserves information in differences in use that can be reliably self-reported while reducing measurement error due to recall bias. Sexual concurrency was evaluated by self-report of any overlapping sexual partnerships for an individual’s past 3 partners. Participants were asked to enumerate current and past sexual relationships and to report if they had sex with anyone else during any of these partnerships. Participants reporting any instance of simultaneous sexual relationships either currently or in the past 12 months were coded as displaying concurrency. This measure was developed following best practices recently recommended by USAID [84].

Measures of centrality of and social cohesion were calculated using baseline social network data. Using a roster list including all members of each camp, men were asked to nominate their friends who belonged to their camp by selecting their names from this list. Centrality measures, specifically in-

degree centrality, were calculated as the proportion of people in the individual's camp network who nominated the individual as a friend [95]. In-degree centrality was calculated within each network for each actor using UCINET [93]. Standardized centrality scores were calculated as follows: $\text{Centrality} = \text{InTie}_{ij} / (n_j - 1)$, where InTie_{ij} is the number of ties received by individual i within camp j , and n_j is the total number of actors in camp j .

Each camp network received a structural and a perceived cohesion score. Structural social cohesion measures for each camp specifically captured the construct of structural cohesion, or the minimum number of nodes who, if removed, would disconnect the network, using methods described by Moody and White [75]. Each network received a social cohesion score calculated as the average pairwise connectivity, or the mean of the total number of possible independent paths between all pairs of any two given individuals in the network [75]. We calculated these scores in UCINET [93]. We created matrices of pairwise connectivity scores for each dyad by camp. We converted these matrices to pairwise lists of connectivity values for each camp and used mean of these values as the structural cohesion value for each camp to test hypothesis 3b. We further calculated a measure of perceived social cohesion for each camp by averaging men's responses to a five item scale at the camp level. We used an adapted measure of social cohesion developed by Sampson, Raudenbush, and Earls [94]. Participants responded to statements related to cohesion of camp members on a 4-point Likert-type scale ranging from 1 = strongly disagree to 4 = strongly agree. Statements included "people in my camp are willing to help each other" and "the members of my camp share the same values."

Symptoms of anxiety and depression were measured using the Hopkins Symptom Checklist-25 (HSCL-25) [85], specifically a version of the scale previously translated into Kiswahili and tested in Tanzania [86]. This measure inventories symptoms of anxiety and depression in 25 items (10 related to anxiety, 15 to depression) rated on a 4-point Likert-type scale. The scale has been previously validated in Tanzania [86, 87]. Anxiety scores were calculated by taking the mean of the 10 anxiety-related items in

the HSCL-25. In the sample the anxiety subscale showed good internal consistency at baseline (Cronbach's alpha = 0.94). Depression scores were calculated by taking the mean of the 15 depression-related items in the HSCL-25. At baseline the depression subscale also showed good internal consistency ($\alpha = 0.91$).

Covariates included in all analyses include age, education level, economic status, marital status, and treatment condition. Age was calculated based on reported date of birth; in cases where birthdate was not reported, the participant's reported age in years was used. Participants reported the highest level of education they had completed based on eight possible categories (no education, Standard 4 or less, Standard 5-7, Form 1, Form 2, Form 3, Form 4, Greater than Form 4). For analysis, education responses were collapsed into three categories: primary school or less (responses: no education, Standard 4 or less, Standard 5-7); some secondary school (responses: Form 1, Form 2, Form 3); or secondary school completed or greater (responses: Form 4, Greater than Form 4). Socioeconomic status (SES) was evaluated through an asset index, the Filmer Pritchett Wealth Index [91]. Participants were asked to indicate which of 10 possible assets they owned (e.g. cellphone, television) [92] and a composite score was created by weighting each asset by its loading on the first component in a principle components analysis and then placing individuals on a continuous scale of relative wealth [91]. The composite score for each participant was categorized into terciles based on the entire sample of men and women in our baseline dataset (the lowest 33% of participants were classified as "lowest SES," the highest 33% were classified as "highest SES," and the remainder were classified as "middle SES"). Marital status was evaluated through a single yes/no item in which men were asked if they had ever been married. Finally, as the intervention being evaluated is designed to affect condom use and sexual partner concurrency, treatment condition (treatment or control) was included as a covariate to account for this design effect in all analyses.

Analysis

All statistical analyses were conducted in SAS v 9.4 and used a 2-sided significance level of 0.05. To address missing data from the behavioral survey (primarily due to attrition), we applied sequential multiple imputation using the fully conditional specification in *proc MI*. Forty imputations were created using a linear regression specification for continuous variables and a logistic regression specification for categorical variables. To account for missing network ties in the calculation of structural cohesion and in-degree centrality discussed above, we conducted imputation by reconstruction as recommended by Huisman [97]. Specifically, we used random imputation of ties proportional to the observed network density (i.e., the probability of a tie is equal to the observed density of each network), as described by Huisman as an extension of Stork and Richard's method of reconstruction [97].

To test the primary hypothesis while accounting for dependence due to clustering within camps, we fit multilevel models with a generalized link function. All models were fit using *proc glimmix* with quadrature estimation (using 15 quadrature points), random intercepts, and logit and cumulative logit link functions (for dichotomous concurrency, and three-level condom use, respectively). For all models the dependent variable was sexual risk (condom use or concurrency) measured at the follow-up, controlling for baseline sexual risk and the covariates listed above. The primary predictors were the baseline value of each hypothesized moderator, change in anxiety or depression (baseline score subtracted from follow-up score), and their interaction.

Anxiety and depression are highly comorbid, and this was observed at the symptom-level in our sample (the correlation between symptoms of anxiety and depression was 0.76 at baseline and 0.74 at the follow-up). We were concerned that collinearity between measurements of their symptoms would limit the ability to interpret the independent effects of anxiety and depression when estimated simultaneously. For this reason, we tested three models for each combination of the three hypothesized moderators and the two sexual behavior dependent variables (for a total of 18 models): 1) Change in

anxiety symptoms only; 2) change in depression symptoms only; and 3) Change in both anxiety and depression symptoms. For each model, we assessed the interaction between mental health and each respective cohesion or centrality score.

6.3 RESULTS

1113 sexually active men were included in all analyses. Regarding observed network characteristics, the average in-degree centrality at baseline was 0.37 (on average 37% of network peers nominated the individual as a friend; SD: 0.23), and the average network cohesion score was 5.95 (SD: 4.72). Men’s perceptions of their camps’ cohesion was relatively high, with an average score of 1.53 (range 1 to 5 with lower scores corresponding to greater perceived cohesion). Structural social cohesion was minimally correlated men’s perceptions of their camp’s cohesion ($\rho = 0.035$).

Table 14. Baseline description of hypothesized moderators

	Mean \pm SD
<i>Observed network measures</i>	
Centrality (popularity)	0.37 \pm 0.23
Network structural cohesion	5.95 \pm 4.72
<i>Perceived cohesion</i>	
	1.53 \pm 0.50

With regard to condom use, there was some trend indication that structural cohesion was associated with condom use, but there were no statistically significant associations with any hypothesized moderators, nor were there any significant interactions with either anxiety or depression. None of the hypothesized moderators of cohesion or centrality were significantly associated with concurrency, nor were there any significant interactions with either anxiety or depression in association with concurrency.

Table 15. Condom use – cohesion and centrality interaction model results

	Moderator		
	Structural cohesion	Observed centrality	Perceived cohesion
	aOR (95%CI)	aOR (95%CI)	aOR (95%CI)
1. Anxiety and peer condom use			
ΔAnxiety	0.83 (0.68, 1.03)†	0.83 (0.67, 1.02)†	0.83 (0.68, 1.02)†
Mod	0.97 (0.94, 1.00)†	0.63 (0.32, 1.25)	1.00 (0.81, 1.23)
ΔAnxiety*Mod	1.00 (0.96, 1.04)	1.07 (0.48, 2.38)	1.07 (0.84, 1.37)
2. Depression and peer condom use			
ΔDepression	0.76 (0.62, 0.91)	0.75 (0.62, 0.90)**	0.75 (0.62, 0.91)**
Mod	0.97 (0.94, 1.01)†	0.62 (0.31, 1.23)	1.01 (0.82, 1.25)
ΔDepression*Mod	1.00 (0.97, 1.04)	1.25 (0.59, 2.62)	1.03 (0.82, 1.30)
3. Anxiety, depression, and peer condom use			
ΔAnxiety	1.08 (0.80, 1.47)	1.08 (0.80, 1.46)	1.08 (0.79, 1.47)
ΔDepression	0.72 (0.54, 0.95)	0.71 (0.54, 0.94)*	0.71 (0.54, 0.94)*
Mod	0.97 (0.94, 1.01)†	0.62 (0.31, 1.23)	1.01 (0.82, 1.24)
ΔAnxiety *Mod	0.98 (0.93, 1.04)	0.76 (0.23, 2.46)	1.05 (0.72, 1.52)
ΔDepression*Mod	1.02 (0.96, 1.07)	1.51 (0.51, 4.45)	1.00 (0.71, 1.42)

† p<0.1; *p<0.05; **p<0.01; ***p<0.001

Table 16. Concurrency – cohesion and centrality interaction model results

	Moderator		
	Structural cohesion	Observed centrality	Perceived cohesion
	aOR (95%CI)	aOR (95%CI)	aOR (95%CI)
1. Anxiety and peer concurrency			
ΔAnxiety	1.60 (1.28, 2.00)***	1.60 (1.28, 2.00)***	1.59 (1.27, 2.00)***
Mod	1.00 (0.96, 1.04)	1.01 (0.47, 2.16)	1.03 (0.83, 1.29)
ΔAnxiety*Mod	1.00 (0.95, 1.05)	0.81 (0.31, 2.09)	1.00 (0.75, 1.33)
2. Depression and peer concurrency			
ΔDepression	1.57 (1.27, 1.95)***	1.58 (1.27, 1.95)***	1.57 (1.27, 1.94)***
Mod	1.00 (0.96, 1.04)	1.04 (0.48, 2.24)	1.03 (0.83, 1.28)
ΔDepression*Mod	1.00 (0.96, 1.05)	1.30 (0.52, 3.25)	1.03 (0.79, 1.33)
3. Anxiety, depression, and peer concurrency			
ΔAnxiety	1.28 (0.94, 1.74)	1.28 (0.94, 1.74)	1.28 (0.94, 1.74)
ΔDepression	1.34 (1.00, 1.78)†	1.34 (1.00, 1.79)†	1.33 (1.00, 1.78)†
Mod	1.00 (0.96, 1.04)	1.03 (0.48, 2.22)	1.02 (0.82, 1.27)
ΔAnxiety *Mod	1.00 (0.93, 1.07)	0.44 (0.11, 1.72)	1.01 (0.66, 1.55)
ΔDepression*Mod	1.00 (0.94, 1.07)	2.28 (0.62, 8.40)	1.03 (0.70, 1.50)

† p<0.1; *p<0.05; **p<0.01; ***p<0.001

6.4 DISCUSSION

None of the hypotheses were supported. Structural cohesion, perceived cohesion, and network centrality were not significantly associated with sexual risk behavior, nor did they interact with anxiety or depression in association with sexual risk behavior.

Prior to this research, there were no studies to my knowledge evaluating these hypothesized relationships, nor the direct relationship between network centrality or cohesion and sexual risk behaviors. There is evidence in the literature, though limited, that network centrality predicts receipt of social support [80], which in turn is related to sexual risk behaviors [81, 82]. This evidence suggests social support as the mechanism through which network and centrality and social cohesion may work to buffer the relationship between mental health and sexual risk behaviors. It also indicates a need for future studies to better understand the effects of network structure and position on the relationship between mental health and sexual risk, and other stress and coping relationships.

The fact that we found no association between perceived or structural cohesion and men's risk behaviors, and no significant interaction with mental health may be due the fact that the intra-class correlation between sexual risk behaviors by camp was relatively low (6.0 percent for condom use and 3.4 percent for concurrency) [170]. Therefore, there was limited variance in condom use and concurrency that was attributable to camp membership which could be explained by camp-level measures of cohesion. With regard to the lack of an observed interaction between men's centrality and their mental health in association with risk behaviors, it is possible that though men were more central had more friends than less central men (by definition), that the social support which they received was not of higher quality. Future studies should seek to understand the relationship between network centrality and perceptions of social support.

CHAPTER 7: DISCUSSION AND CONCLUSION

The purpose of this dissertation was to examine the role of anxiety and depression as predictors of sexual risk behaviors among a population of young men living in Dar es Salaam, Tanzania, and to understand the moderating role of normative and supportive elements of young men's peer networks in this relationship. The study was conducted among a population of socioeconomically marginalized young men living in Dar es Salaam belonging to social groups known as "camps," which were identified as important venues for the prevention of intimate partner violence and sexual risk behaviors by the parent study team. The results of the dissertation study contribute important understanding of the psychosocial risk factors for sexual risk behaviors in this key population, and provide important implications for the development of future HIV prevention interventions in this and similar populations.

7.1 Summary of Findings

Aim 1. In the first paper corresponding to the results of Aim 1 (Chapter 4), I found that many men experienced clinically significant symptoms of anxiety and depression (19% and 21%, respectively at baseline). I learned that changes in anxiety and depression were significantly associated with both condom use and concurrency. A secondary model indicated that anxiety and depression may independently affect concurrency but depression may be the primary predictor of condom use. This model suggested that the observed relationship between anxiety and condom use may be attributable to the covariance between anxiety and depression symptoms. These findings provide important evidence of the longitudinal association between mental health and HIV risk in a primarily heterosexual

population of young men in a sub-Saharan urban setting. They also provide much needed understanding of the longitudinal relationship between anxiety and sexual risk in this setting.

Aim 2. In the second paper corresponding to the results of Aim 2 (Chapter 5), I found that changes in perceived norms were associated with young men's behaviors, and that these norms interacted with anxiety to shape sexual risk. Specifically, I found that perceived descriptive norms were associated with both condom use and concurrency, perceived injunctive norms were associated with concurrency, and direct encouragement was associated with condom use. Changes in perceived condom use norms (descriptive norms and encouragement) also interacted with changes in anxiety symptoms to shape condom use. There was not a significant correlation between these perceived norms and the observed behaviors of men's closest friends. Changes in the observed behaviors of men's closest friends were also not associated with men's own behaviors. I further found no evidence of peer influence in comparing observed behaviors among men's closest friends and in their larger camp networks. The results of this study provide novel evidence of the interacting effects of poor mental health and risky perceived sexual behavior norms among a hard to reach population of marginalized young men in Dar es Salaam. The findings provide important information for future norms-based and mental health promotion interventions targeting HIV prevention in this key population.

Aim 3. In the results for Aim 3 (presented in Chapter 6), I found no significant associations between men's sexual behaviors and structural cohesion, perceived social cohesion, or centrality. None of the hypothesized interactions were significant. There was some trend indication that structural cohesion was associated with condom use. As no significant results were found pertaining to Aim 3, they were left out of the second manuscript to be able to present the results related to social norms in more detail, and to be able to present a cohesive narrative in the manuscript.

7.2 Study Strengths

The dissertation study provides important longitudinal evidence of the relationship between mental health and sexual risk in a population of young men living in Dar es Salaam, and the extent to which this relationship is socially influenced. The sociocentric network data from 59 camps of 1249 men available from the parent trial presented the rare opportunity to explore the influence of the observed behaviors of social network peers, and structural elements of the peer network on the relationship between mental health and sexual risk. These strengths are discussed in further detail below.

Key population

The men included in this study represent an important yet hard to reach population. Youth in Tanzania are disproportionately affected by HIV [1], and men are important targets in preventing HIV as gender norms position them to control the terms and conditions of sexual relationships [4], and encourage them to engage in high risk sexual behaviors including inconsistent condom use and sexual partner concurrency [3, 5-8]. Half of sexually active male youth (ages 15-24) surveyed in Tanzania in 2010 did not use a condom at last intercourse [4]. Further, nearly one third of young men in Tanzania reported concurrent sexual relationships in 2010 [4], making condom use and concurrency important target risk behaviors in this population. Many high risk youth are difficult to access for systematic research as they may not be enrolled in school or formally employed. The participants of the dissertation study represent one such difficult to reach population.

The participants in the parent trial who are also included in this study are male members of social groups known as “camps.” These groups’ spaces were identified by the parent study team as important venues for the prevention intimate partner violence and HIV risk behaviors. An estimated 70% of the Dar es Salaam's population lives in informal settlements [22]. As these camps are located in areas of the city with the lowest income and highest concentration of informal housing, men in camps

represent an important but hard to reach population in the city. Most of the men in these camps are neither in school nor formally employed [28], thus these venues serve as key entry points to understand behavior in a high risk group. Further, these types of camp groups the participants belong to are found elsewhere in eastern and southern Africa [187-190]. Because of changes in the global economy leading to high youth unemployment, the type of population seen in this study may be growing; more and more youth in urban areas of developing countries around the world are participating in social groups or gangs that are similar to the camps I studied [191]. For these reasons, understanding of the social dynamics in these groups which shape sexual risk behaviors may be generalizable to similar hard to reach groups of men throughout the region.

Longitudinal evidence of important risk relationships

The dissertation research provides important understanding of the critical relationship between symptoms of anxiety and depression, and sexual risk behaviors in this key population. The results provide much needed longitudinal evidence of the relationship between internalizing symptoms and HIV risk behaviors among a population of primarily heterosexual men in sub-Saharan Africa. Prior to the dissertation study, we primarily had evidence of cross-sectional associations between both anxiety and depression, and sexual risk behaviors [5-10]. In the extant literature, we had little understanding of the longitudinal association between these internalizing behaviors and sexual risk [8, 9, 11, 12, 49]. We further had limited understanding of such a risk relationship from populations in sub-Saharan Africa, as the bulk of the evidence supporting these relationships came from the United States and other high income contexts [5, 8, 10-15]. Further, due to its prevalence and frequent comorbidity with depression [106], the results provide important evidence of the role of anxiety as a predictor of sexual risk. Such an understanding is particularly needed in this context, as there has been only one prior study examining anxiety as a predictor of sexual risk in a sub-Saharan population to my knowledge [7]. The results of this

study bring us closer to a causal understanding of the relationship between mental health and sexual risk in this context. Future research is needed to fully determine the causality of this relationship which I discuss in further detail in the Limitations section of this chapter.

Social network data

The data available from the parent trial provided access to both egocentric and sociocentric network data within each camp. The availability of information about men's friendships, and the ability to link these data to the reported behaviors of these friends provided two advantages in the dissertation study: 1) the ability to compare the role of observed peer behaviors and perceived behavioral norms; and 2) the ability to understand the moderating role of not only perceived but also structural measures of popularity and social cohesion in the relationship between mental health and sexual risk. By being able to compare friends' observed behaviors and men's normative perceptions of these behaviors, the results raise important questions for future norms-based interventions about the relative salience and relationship between peers' actual behaviors and individuals' perceptions of these behaviors. These implications are discussed further in the Implications for Future Research section of this chapter.

Regarding the ability to assess centrality and social cohesion as moderators of the main effect relationship, though I found no significant moderation by either of these factors, the results provide important preliminary understanding of the role of social networks in shaping the relationship between mental health and sexual risk. It is important to continue to build understanding of peer influence in this relationship as it will allow us to discern if there is something social or learned about sexual risk as a response to poor mental health. This study attempted to understand how to intervene within networks to reduce sexual risk, though I found no evidence that camp social network structure could serve to buffer the relationship between mental health and sexual risk behaviors.

7.3 Study Limitations

There are a number of limitations to this study which may suggest caution in the interpretation of the results. These limitations include: 1) the temporal nature of the two observations used which limits the ability to draw causal conclusions about the associations found; 2) the measurement of sexual behavior by self-report; 3) the measurement of anxiety and depression using a scale which was not developed for this population; 4) the inability to represent the influence of important peers outside of the camp networks. Each limitation is discussed in detail below.

Evaluation of longitudinal relationships

The two time points used in this study as measured a year apart do not allow me to establish whether affective manifestations of anxiety and depression directly precede decisions to engage in risky sexual behaviors. Though there is an established temporal relationship between changes in internalizing symptoms and sexual risk in this study, event-level data is needed to establish the precise temporal relationship [126]. Within the limitations of the data available, the hypotheses as tested allow me to establish that changes in anxiety and depression are associated follow-up sexual behaviors taking into account baseline sexual behavior in this population.

Likewise, with the present data I cannot say if a changes in norms and mental health precede changes in men's sexual behaviors. It is possible that the observed association between changes in perceived norms and men's behaviors are the result of a false consensus effect, i.e. that men's perceptions of norms changed to match their own behaviors. Experimental research with successful manipulation of perceived norms is needed to better determine the temporal direction of a potential causal relationship between perceived norms and these behaviors. With the current analysis I am able to assess the association of changes in social norms with men's behaviors at the follow-up controlling for their baseline behavior. Though the change predictors included in the models indicate that within-

individual changes in perceived norms were associated with men's behaviors, future research is needed to better determine the temporality in these relationships, i.e. to determine if changes in perceived norms precede changes in behaviors or vice versa. It is also possible that norms and behaviors are mutually deterministic, that norms shape behaviors and perceived norms may in turn be revised to align more closely with one's own behaviors. A better understanding of these relationships is needed to inform norm change interventions, such as popular opinion leader interventions which aim to leverage the normative influence of key community members often used to target HIV risk behaviors [184-186].

Measurement of sexual behavior

Sexual behaviors were measured through self-report in this study. Respondents' willingness to report sexual risk behaviors may have been associated with the social acceptability of such an acknowledgment. In addition, reports of sexual risk behaviors were retrospective, and thus recall bias may be an issue. To reduce the influence of social desirability bias in men's responses regarding their sexual behavior, we trained data collectors to establish a rapport with participants and to ask questions as nonjudgmentally as possible. We also used introductory scripts to sets of questions about condom use and concurrency behaviors to remind participants that their responses were strictly confidential, and to normalize the reporting of concurrency behaviors by stating that there is great variety in people's sexual relationships, including the number of sexual partners a person has, and the gender of sexual partners.

I was also careful about the coding of the condom use and concurrency to minimize the influence of recall bias; concurrency was captured dichotomously rather than attempting to quantify the number of concurrent relationships. The measure of concurrency used was developed following best practices recently recommended by USAID [84]. Regarding condom use, because of the possibility of some degree of recall bias over the course of the three most recent relationships, use of a continuous

variable of condom use is not indicated as each unit increase would not necessarily indicate an important difference in condom use. Dichotomizing condom use, however, is not recommended by Noar et al. [83], thus I used a three-level categorical condom use variable to preserve information in differences in use that can be reliably self-reported while reducing measurement error due to recall bias.

Measurement of anxiety and depression

Symptoms of anxiety and depression were measured through retrospective self-report of symptoms over the past week. The HSCL-25 scale which was used to measure anxiety and depression was developed in a different cultural context than the study setting. We used a version of the scale previously translated into Kiswahili and tested in Tanzania [86]. The scale has been previously validated in Tanzania [86, 87]. Given this evidence, I feel comfortable with the theoretical validity of the scale's measurement of anxiety and depression symptoms in this population. This said, given that anxiety and depression symptoms were reported over the past week only, I cannot state that levels of symptoms are reflective of enduring traits of anxiety or depression as opposed to shorter-term states of anxiety or depression which may be highly contextually influenced.

Important relationships outside of camp networks

Finally, men were asked only about their friendships within their own camp, thus the results relating to social norms, centrality, and social cohesion cannot account for the role of important relationships outside of men's camp networks. Specifically in relation to peer norms, there may be other influential peers and family members outside of camp network who serve as important normative reference groups in men's behavioral decision-making. These norms are not captured in these analyses. Nevertheless, the relationships and associated norms captured in this study reflect an important peer

group for men belonging to these camps. The fact that men's perceptions of camp friends' behaviors were associated with their own behaviors suggests that these friends are an important normative reference group for these men. Further, in naming their closest friends, men were limited to three nominees which may have excluded other close friends who participants may consider to be just as close as those named. Future studies might rather seek to set a higher limit or have no limit to the number of friends who men can name as close friend.

7.4 Implications for Future Research

The dissertation research raises a number of questions for future research. I discuss the most important questions raised by the study here.

In high HIV prevalence contexts, who is most at risk of poor mental health?

Anxiety and depression are among the most important causes of morbidity globally [193]. Though there are few nationally representative estimates of the prevalence of anxiety and depression in African nations like Tanzania, studies of primary care and HIV treatment clinic populations found approximately a 15% prevalence of depression and a 5-7% prevalence of anxiety [25, 26]. In this study I estimated the prevalence of clinically significant symptoms of anxiety and depression in this population to be about 20%, respectively. Because of the scarcity of mental health resources in Tanzania, we need to understand who is most at risk of anxiety and depression to determine how to best target the existing services to those most in need. There has been little research to date in low resource settings like Tanzania to understand the determinants of depression and anxiety. Among studies conducted in sub-Saharan Africa, depression and associated disorders have been associated with age [134, 135], marital status [134, 136, 137], education [136, 138], and employment and income [135, 136, 138]. There is also evidence that women are at greater risk of depression than men in this setting [134, 136]. Despite the

higher prevalence of depression among women in the literature, the substantial levels of clinically significant symptoms of anxiety and depression among young men in the study population should not be discounted. We need more research specific to men as the determinants of anxiety and depression are likely to be different among men than among women [134, 136].

Why might anxiety relate to concurrency but not condom use?

As depression and anxiety are highly comorbid, I sought to disentangle the respective associations between changes in symptoms of anxiety and depression, and sexual risk behaviors. The analyses suggested that both depression and anxiety were independently associated with concurrency but that most of the observable association between anxiety symptoms and condom use could be attributed to anxiety's covariance with depression. As most research on this topic to date has focused on depression alone as a risk factor for sexual risk behaviors, this represents an important contribution to our understanding of the role of anxiety in this risk pattern. There are multiple theorized pathways through which negative affect in the form of symptoms of anxiety and depression may lead to sexual risk behaviors, including substance use[10], maladaptive coping to deal with stress [47], and impaired decision making [48].

Such mechanisms may help to explain the finding that depression and not anxiety seemed to be independently associated with condom use. Because of the hopelessness, sense of futility, and tendency toward self-destructive behaviors associated with depression [120], men experiencing greater levels of depression may be less likely to use condoms. While the experience of depression is associated with lower condom use, men with symptoms of anxiety may have a range of experiences of anxiety that affect condom use differently. While some individuals may experience excessive worry [121], which may lead to vigilance about condom use, others may experience impulsivity [122] that could lead to disregard for condom use. I hypothesized in the first paper (Aim 1) that if at the individual level feelings

of anxiety encourage or discourage condom use differently for different men, at the population level there may be no consistent observable relationship between general symptoms of anxiety and condom use. I further suggested that future studies should seek to understand how different anxious tendencies (e.g. worry-type vs. impulsive-type) relate to condom use. In the second paper (Aim 2) I found that the relationship between anxiety and condom use was moderated by perceived condom use norms (descriptive and injunctive norms), and that this relationship held when depression was controlled for. It is possible that the normative context may serve to partially suppress the observed relationship between anxiety and condom use.

Why might behavioral norms interact with anxiety and not depression, and only in relation to condom use?

In the second paper (Aim 2) I found an interaction between anxiety and behavioral norms in relation to condom use, but not in relation to concurrency. Further, there were no significant interactions with depression in relation to either behavior. Future studies should seek to understand why perceived norms might not interact with depression to shape young men's sexual behaviors, and why norms related to concurrency may not magnify the effect of mental health on concurrency as they seem to do for condom use.

Previous research regarding the interaction between mental health and peer norms with regard to alcohol consumption have found interactions with both depression and anxiety symptoms. One study found that worse mental health in combination with risky peer drinking norms led to more negative outcomes related to drinking behavior [171]. Similarly, a study among college students found that perceived peer drinking norms moderated the association between social anxiety and alcohol use [176], and another study found a similar relationship for depressive symptoms [177]. To my knowledge, the dissertation research represents the only study to date to test the interaction between mental health and social norms in relation to sexual risk behaviors. Future studies should seek to replicate these

findings to confirm the importance of the specific findings relating to the interaction between anxiety and condom use norms.

Why do different types of norms seem to matter for different behaviors?

In the second paper I found that perceived descriptive norms were associated with both condom use and concurrency, but that injunctive norms were specifically related to condom use, as direct discouragement was to concurrency. Future studies should seek to replicate these findings in other populations. Research is also needed to understand why the effect of injunctive norms and direct encouragement (or peer pressure) would differ by behavior. Previous studies have found injunctive norms to be associated with both condom use [194] and concurrency [195], and have found the same for direct peer encouragement of condom use [196]. For this reason, replication of these findings in other populations is needed before attempting to develop a theoretical understanding of the connections between different behaviors and injunctive and encouragement norms. A better understanding of these relationships and potential mechanisms explaining them would help to understand how to target different types of norms for different behaviors to optimize HIV prevention interventions. Qualitative studies to understand potential differences in the way that men perceive the importance of peer approval and encouragement of different behaviors would be particularly illuminating.

What shapes perceived norms if not friends' actual behaviors?

In the second paper I found no significant correlations between men's perceptions of their friends' behaviors and their friends' own self-reported behaviors. As I found that changes in perceived norms were associated with men's sexual risk, it is important to build understanding of what shapes perceptions of sexual behavior norms among youth if not their peers' actual behaviors. Such an

understanding would help to identify important psychosocial targets for behavioral HIV prevention interventions. It should also be considered that perceived norms may indeed reflect peer behaviors, but that individuals may disproportionately weight the behaviors and attitudes of specific peers. Theory indicates that the behavior of highly popular, or highly connected, individuals are more influential than less popular individuals [197]. While perceptions of norms may be particularly shaped by popular peers, they may additionally reflect personal behaviors and previously formed behavioral attitudes and values. Because of the importance of norms perceptions for risk behavior among youth, understanding the relative influence of these factors will be important for the development of group-level risk reduction interventions.

Though perhaps counterintuitive, the lack of correlation I found between friends' self-reported behaviors and men's perceptions of them is similar to previous findings in this population with regard to perceptions of friends' HIV testing [178]. Indeed, individuals' perceptions of norms pertaining to any behavior are related to observable peer behaviors, but these perceptions rarely match what peers are actually doing as perceptions of norms are filtered through each individual's unique position and perspective [179]. Previous research has shown that individuals tend to underestimate their peers' protective behaviors and overestimate their risky behaviors [180]. Other studies have observed a false consensus effect, observing a tendency to misperceive peer behavior in a direction that is that is consistent with their own behavior [181, 182]. Further, as people have limited opportunity to observe their friends' behaviors, they often take mental shortcuts and unconsciously extrapolate ideas of descriptive norms using availability heuristics, interpreting norms from observations and stored memories that are most readily available [183]. For example, a peer who has a second concurrent partner may draw more interest or attention than peers who have only one partner, making the examples of concurrency more cognitively available. Taken together, these psychological biases suggest that in addition to targeting normative opinions among popular or prominent members of a social

group, it may be important to also address realistic perceptions of peer behaviors and attitudes toward risky behaviors, as seen in many college substance use myth busting campaigns [198].

7.5 Intervention Implications

The results of this study have many implications for HIV prevention and related interventions in Dar es Salaam and similar contexts. Chief among these implications are: 1) the need to find feasible approaches to address the burden of anxiety and depression in low-income contexts, particularly in settings with a high HIV prevalence; 2) the importance of targeting individual perceptions to reduce the overestimation of peer risk behaviors; and 3) the importance of targeting multiple risk factors to more holistically account for the susceptibilities which make youth more likely to engage in sexual risk behavior. I discuss both of these implications in further detail below.

Addressing the burden of internalizing disorders in low-income, high HIV prevalence contexts

I estimated the prevalence of clinically significant symptoms of anxiety and depression in this marginalized population of men to be about 20%, respectively. Beyond the study population, very little is known about the mental health of Tanzania's population. There are no estimates of the prevalence of common mental disorders including anxiety and depression to my knowledge, though there have been studies which provide estimates for specific populations. In one study of primary care attendees, the prevalence of depression and "mixed anxiety-depressive disorder" were 15% and 7%, respectively [25]. In another study of HIV-positive patients in rural Tanzania, 16% of patients presented symptoms of depression, and 5% suffered from other anxiety disorders [26]. Though I cannot speak to the prevalence of anxiety and depression in the general population in this setting, the level of mental health services in Dar es Salaam and indeed throughout Tanzania inevitably cannot address the burden of both disorder

classes in the population; per 100,000 population in Tanzania there are only 2 psychiatric nurses, 0.04 psychiatrists, and 0.005 practicing clinical psychologists [27].

Given the paucity of services available and the levels clinically of significant symptoms of anxiety and depression among one out of five men in the study population, efforts to screen and provide treatment for depression and anxiety disorders are indicated as a potentially important component of primary HIV prevention in this setting. Promising models of mental health promotion which may be scalable in this setting include training nurses to implement mental health screening and treatment [129, 130], or even training lay people to screen for common mental disorders to be able to refer individuals meeting clinical criteria to counseling [131-133]. While there are promising interventions to address depression in this context [128, 129], we need more efforts to intervene upon anxiety in low resource settings to the end of reducing sexual partner concurrency at the population level.

The results of this study further indicate the development of effective HIV prevention interventions targeting young men living with anxiety and depression. Because of the indication of my findings that men with worsening symptoms of anxiety and depression may be at greater risk of sexual risk behaviors, efforts to address mental health among high risk populations may contribute to lowering the incidence of HIV. In addition, targeting HIV prevention interventions to sub-populations with higher burdens of anxiety and depression may also prove beneficial to HIV prevention. Previous HIV prevention trials for women have been more effective when they have also been able to improve mental health [127], and we need to test whether such interventions would prove effective among young men as well.

Focusing social norms messaging targeting sexual behavior

As I found that men's perceptions of peer behaviors did not match their friends' actual behaviors, social norms interventions aiming to prevent sexual risk should consider promoting less risky perceived norms rather than or in addition to targeting the behavior of influential individuals. Popular opinion leader

interventions have long attempted to influence group behavior by identifying influential individuals and encouraging them to model behavior and express negative attitudes toward risk behaviors [184-186]. In addition to such interventions, it will be important to develop individual-level interventions to target inaccurate and risky perceptions of sexual behavior norms. As people often overestimate their peers' risk behaviors [76], it may be effective to promote realistic perceptions of peer behaviors and attitudes toward risky behaviors. One successful approach to accomplish this is found in myth-busting interventions, which are often seen in university campaigns to reduce substance use [198]. This approach has also been used to increase condom use and reduce partner concurrency among college students; a brief intervention in which students were asked to estimate condom use and concurrency levels among their peers, and then to compare these estimates to actual data from a campus survey, was effective in increasing condom use and reducing partner concurrency [199]. The feasibility of such interventions is contingent upon the availability of risk behavior data from a salient peer reference group. Where such data are available, the efficacy of this type of intervention should be evaluated among marginalized youth.

Multi-pronged HIV prevention programs

Because of the evidence from this study that mental health and social norms may interact to shape men's condom use behavior, future HIV prevention interventions should consider the importance of targeting perceived social norms and mental health simultaneously. In norms-focused interventions, it may be important to consider how participants' mental health, specifically anxiety, could affect the success of the intervention. In programs aiming to promote mental health, interventionists should consider the additional importance of condom use and concurrency norms, and aim to target perceptions of risky norms to prevent risk behaviors in high HIV prevalence populations. No such combined intervention has ever been conducted to my knowledge. These measures will be particularly

important among marginalized populations similar to the camps in the study, as men living in high HIV-prevalence contexts may be exposed to multiple susceptibilities to risk behaviors, including poor mental health and risky social norms.

APPENDIX A: HSCL-25 ITEMS

HSCL-25 items

How much did each of the following symptoms bother or distress you in the last week, including today? 1. Not at all; 2. A little; 3. Quite a bit; OR 4. Extremely

ANXIETY SUB-SCALE

1. Suddenly scared for no reason
2. Feeling fearful
3. Faintness, dizziness, or weakness
4. Nervousness or shakiness inside
5. Heart pounding or racing
6. Trembling
7. Feeling tense or keyed up
8. Headaches
9. Spells of terror or panic
10. Feeling restless, can't sit still

DEPRESSION SUB-SCALE

11. Feeling low in energy, slowed down
12. Blaming yourself for things
13. Crying easily
14. Loss of sexual interest or pleasure
15. Poor appetite
16. Difficulty falling asleep, staying asleep
17. Feeling hopeless about the future
18. Feeling blue
19. Feeling lonely
20. Thoughts of ending your life
21. Feeling of being trapped or caught
22. Worrying too much about things
23. Feeling no interest in things
24. Feeling everything is an effort
25. Feelings of worthlessness

APPENDIX B: SEXUAL BEHAVIOR ITEMS

Script: I would now like to ask you about your sexual relationships. When I talk about having sex I mean that you had either vaginal or anal sex with the person.

Many people have different types of sexual partnerships. Some sexual partners are people we have sex with once or twice and some sexual partners are people we have sex with regularly. Some people have many sexual partners and other people have fewer sexual partners. Some people have sex with partner of the same gender.

In the past 12 months, you mentioned that you have had sex with # people. I would like to begin by asking you about the person you have had the longest sexual relationship with during the last 12 months.

No.	Questions and Filters	Coding Categories
Q1501	Tell me about the person you have had the longest sexual relationship with. What is the nickname or initials I could use to talk about this person?	<hr/> PARTNER #1
Q1502	When was the most recent time you had sex with PARTNER 1?	MONTHS ___ __ WEEKS ___ __ DAYS ___ __
Q1503	Is PARTNER 1 a man or a woman?	MAN WOMAN
Q1505	How long have you been having sex with this partner?	YEARS _____ MONTHS _____ WEEKS _____
Q1506	What type of relationship do you have with PARTNER 1?	SPOUSE POLYGAMOUS SPOUSE COHABITING PARTNER GIRLFRIEND/BOYFRIEND FRIEND CASUAL ACQUAINTANCE COMMERCIAL SEX WORKER ONE TIME PARTNER OTHER _____
Q1509	Are you still having sex with PARTNER 1?	NO YES
Q1510	How often do/did you have sex with PARTNER 1?	EVERY DAY A FEW TIMES A WEEK FEW TIMES A MONTH ABOUT ONCE A MONTH ONLY 1-2 TIMES EVER

No.	Questions and Filters	Coding Categories
Q1511	During the last (most recent) time you had sex with this partner, did you use a condom?	NO YES DON'T KNOW
Q1512	How many times would you say you had sex with PARTNER 1 during the last one month you had sex with him/her?	_____
Q1513	Of these (Response from Q1512) times, how many times would you say you used a condom?	_____
Q1519	While you were in a sexual relationship with PARTNER 1, did you have sex with anybody else?	NO YES
Q1520	As far as you know, during the time you were having a sexual relationship with PARTNER 1, do you think PARTNER 1 had sex with other people?	NO YES
Q1521	How confident are you that you can use a condom with PARTNER 1?	VERY CONFIDENT SOMEWHAT CONFIDENT NOT AT ALL CONFIDENT

APPENDIX C: SOCIAL NORM ITEMS

No.	Questions and Filters	Coding Categories
Q1212	Do you think FRIEND 1 uses condoms all the time?	NO YES
Q1213	Do you think FRIEND 1 thinks that he/she should be using condoms all the time?	NO YES
Q1214	Has FRIEND 1 encouraged you to use condoms all the time?	NO YES
Q1215	Do you think FRIEND 1 has more than one sexual partner at the same time?	NO YES
Q1216	Do you think FRIEND 1 thinks that it's ok for him/her to have more than one sexual partner at the same time?	NO YES
Q1217	Has FRIEND 1 discouraged you from having more than one sexual partner at the same time?	NO YES

APPENDIX D: PERCEIVED SOCIAL COHESION ITEMS

Script: Now I'd like to ask you a few questions about how you and your fellow camp members get along in this camp. For each statement, please tell me whether you strongly agree, agree, strongly disagree, or disagree with the statement. When answering these questions, keep in mind that I'm asking you to say whether you agree with the statement based on what is true for **you**, not what other people think is true or what your camp thinks is true.

No.	Questions and Filters	Coding Categories
Q401	People in my camp are willing to help each other.	<p style="text-align: right;">STRONGLY AGREE AGREE DISAGREE STRONGLY DISAGREE</p>
Q402	We are very close to each other in this camp.	<p style="text-align: right;">STRONGLY AGREE AGREE DISAGREE STRONGLY DISAGREE</p>
Q403	I can trust my fellow camp members.	<p style="text-align: right;">STRONGLY AGREE AGREE DISAGREE STRONGLY DISAGREE</p>
Q404	The members of my camp get along with each other.	<p style="text-align: right;">STRONGLY AGREE AGREE DISAGREE STRONGLY DISAGREE</p>
Q405	The members of my camp share the same values.	<p style="text-align: right;">STRONGLY AGREE AGREE DISAGREE STRONGLY DISAGREE</p>

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