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Evidence of social network influence on multiple HIV risk behaviors and normative beliefs among young Tanzanian men

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Abstract

Research on network-level influences on HIV risk behaviors among young men in sub-Saharan Africa is severely lacking. One significant gap in the literature that may provide direction for future research with this population is understanding the degree to which various HIV risk behaviors and normative beliefs cluster within men's social networks. Such research may help us understand which HIV-related norms and behaviors have the greatest potential to be changed through social influence. Additionally, few network-based studies have described the structure of social networks of young men in sub-Saharan Africa. Understanding the structure of men's peer networks may motivate future research examining the ways in which network structures shape the spread of information, adoption of norms, and diffusion of behaviors. We contribute to filling these gaps by using social network analysis and multilevel modeling to describe a unique dataset

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of mostly young men (n= 1,249 men and 242 women) nested within 59 urban social networks in Dar es Salaam, Tanzania. We examine the means, ranges, and clustering of men's HIV-related normative beliefs and behaviors. Networks in this urban setting varied substantially in both composition and structure and a large proportion of men engaged in risky behaviors including inconsistent condom use, sexual partner concurrency, and intimate partner violence perpetration. We found significant clustering of normative beliefs and risk behaviors within these men's social networks. Specifically, network membership explained between 5.78 and 7.17% of variance in men's normative beliefs and between 1.93 and 15.79% of variance in risk behaviors. Our results suggest that social networks are important socialization sites for young men and may influence the adoption of norms and behaviors. We conclude by calling for more research on men's social networks in Sub-Saharan Africa and map out several areas of future inquiry.

Keywords

Tanzania; young men; social networks; HIV risk behaviors; HIV normative beliefs; clustering; intraclass correlation

INTRODUCTION

Social networks shape health and health behaviors by providing opportunities for social influence, comparison, support, and engagement (Berkman, Glass, Brissette, & Seeman, 2000). Social influence, the process through which an individual's beliefs or behaviors are affected by others, is thought to occur through social norms, modeling of behaviors and consequences, and through social rewards and sanctions (Latkin & Knowlton, 2015). Social norms provide important information on perceived or actual prevalence (descriptive norms) and appropriateness (injunctive norms) of behaviors among peers (Cialdini, Reno, & Kallgren, 1990) and encourage the adoption of norms and behaviors that are common and/or socially acceptable. Individuals may also be driven to adopt beliefs or behaviors through the observation of others, or modeling, and by reflecting on the consequences of that behavior (Bandura, 1977). Additionally, network members may reward individuals or punish transgressions against the norm.

Social networks have been shown to influence a number of HIV risk behaviors including condom use (Barrington et al., 2009), sexual partnership concurrency (Yamanis, Fisher, Moody, & Kajula, 2015), early sexual debut (Ajilore, 2015), as well as drug use and needle sharing (De, Cox, Boivin, Platt, & Jolly, 2007; Lakon, Ennett, & Norton, 2006). These studies have highlighted the important role that peer characteristics (Ajilore, 2015), perceived descriptive norms of network members (Barrington et al., 2009), network structure and composition (De et al., 2007), as well as the interaction between network closeness and descriptive norms (Yamanis et al., 2015) may play in shaping HIV risk behaviors.

Despite the advances in our understanding of network influence on HIV-related behaviors, research on peer network influences on HIV risk and protective behaviors among young men in sub-Saharan Africa is severely lacking. Existing network research in the region has described sexual networks (Helleringer & Kohler, 2007) and have focused on examining

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network influences on perceptions of risk of AIDS (Helleringer & Kohler, 2005; Kohler, Behrman, & Watkins, 2007). Other recent network studies in the region have examined network influences on condom use, but have been conducted with sub-groups of higher-risk men like men who have sex with men (MSM) (de Voux et al., 2015; Nelson et al., 2015). One notable exception is a recent study examining network effects on sexual partner concurrency among young men in Tanzania (Yamanis et al., 2015). This study found that men in more tightly connected networks were more likely to behave according to their peer network's concurrency norms. These results suggest that network-level characteristics are an important source of influence on young men's sexual behavior in this context.

The lack of network research on HIV-related behaviors among sub-Saharan African men is critical because young men are essential targets for HIV prevention in the region. This is because men often have more power within their sexual relationships (Jewkes, Dunkle, Nduna, & Shai, 2010) and also because men's low rates of healthcare utilization have important implications for ongoing antiretroviral treatment as prevention efforts (Mills, Beyrer, Birungi, & Dybul, 2012). The lack of research on network influences on men's HIV risk and protective behaviors in the region is also important because men's HIV-related behaviors and beliefs are shaped by influential factors at multiple levels and intervening effectively requires an understanding of these multilevel influences (Kaufman, Cornish, Zimmerman, & Johnson, 2014). A systematic review of behavioral HIV prevention interventions for young people in sub-Saharan Africa found that many interventions were ineffective in part because they predominantly focused on changing knowledge and attitudes as opposed to utilizing a broader ecological perspective to identify and target other determinants of risk (Michielsen et al., 2010). Many theoretical perspectives, including social learning theory (Bandura, 1977), theory of normative social behavior (Rimal & Real, 2005), and structural theory of social influence (Friedkin, 2006) suggest that peer groups are a major source of influence on individual behavior. We need to understand whether and how peer networks are related to both risk and protective HIV-related behaviors in this context in order to inform the development of innovative, sustainable, and empirically based multi-level interventions that are needed to effectively prevent HIV (Latkin & Knowlton, 2005).

Understanding the degree to which multiple HIV risk behaviors and normative beliefs cluster within naturally occurring social networks may provide direction for future research that is needed to inform multilevel intervention approaches. This would increase our understanding of the degree to which men's friendship groups tend to share the same behaviors and normative beliefs. The reason that friends might hold similar beliefs or engage in similar behaviors could be that individuals are influenced by the behaviors and/or beliefs of their peers and change to conform to their peer (i.e. social influence). Under these conditions, interventions could leverage these social influence processes to encourage and reinforce behavior change through network-based interventions targeting popular or central network members. Alternatively, friends may share similar beliefs and behaviors because individuals seek out peers that are similar to them (i.e. social selection or homophily) (McPherson, Smith-Lovin, & Cook, 2001). In these cases, normative interventions targeting opinion leaders may not be as effective because new ideas may have difficulty gaining traction within networks (Valente, 2010). However, homophily may speed diffusion of new behaviors once these behaviors sufficiently permeate the networks because these groups

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tends to be characterized by high levels of trust and communication (Valente, 1995). Thus, understanding the clustering of normative beliefs and behaviors may help us understand which norms and behaviors have the greatest potential to be socially influenced.

Finally, few network-based studies have previously described the structure of social networks of youth in sub-Saharan Africa. As a result, we know little about the average network structure or ranges we might expect to find with regard to the structural characteristics of naturally occurring networks of youth. The structure of social networks is important to future research because the patterns of relationships between individuals can be used to understand how direct and indirect ties affect health behaviors.

To fill these gaps, we use social network analysis and multilevel modeling methods to describe a unique social network dataset of mostly men (n= 1,249 men and 242 women) nested within 59 randomly selected social networks locally referred to as “camps” in Dar es Salaam. These camp-based social networks have a stable membership and form to socialize and support one another (Yamanis, Maman, Mbwambo, Earp, & Kajula, 2010). Sociocentric network studies, studies of complete social networks, are ideal for assessing the structural characteristics of networks (Marsden, 2002). Because closed social groups with clear boundaries are needed to collect sociocentric network data, camp-based social networks in Dar es Salaam are aptly suited for this method of analysis.

The purpose of this study is to improve our understanding of the structure and composition of young men’s peer networks as well as the levels of HIV-related risk behaviors and normative beliefs of these young men. We specifically examine the means, ranges, and clustering of men’s normative beliefs (including attitudes towards condom use, attitudes towards multiple concurrent partners, attitudes towards intimate partner violence, and gender equitable norms) and behaviors (including sexual activity, age at first sex, lifetime number of sexual partners, past-year number of sexual partners, consistent condom use, sexual partner concurrency, IPV perpetration, alcohol use, and HIV testing) within their naturally occurring social networks. In particular, the aims of the study are to: 1) describe the composition and structure of the social networks enrolled in an on-going cluster-randomized intervention trial, 2) examine the means and ranges of men’s network-level normative beliefs and behaviors, 3) assess the degree to which camp network membership explains variance in men’s normative beliefs and behaviors, and 4) discuss the implications of our findings for future research.

METHODS

Data for this study come from an on-going cluster-randomized HIV prevention trial with youth who socialize in urban social networks locally referred to as “camps”. Previous research with camp networks found that camps are semiformal groups who socialize regularly in a fixed location (Yamanis et al., 2010). Individuals described the support they receive from their fellow camp members when dealing with challenges including finding work and coping with family sicknesses and burial costs. Camps have elected leaders including a chairman and treasurer and leaders maintain rosters of current camp members. Camps have mostly male members with some camps explicitly prohibiting women from

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joining. Other camps, however, embrace women as members and even as leaders (Yamanis et al., 2010). The on-going trial is evaluating the effectiveness of a camp-randomized microfinance and health leadership intervention on sexually transmitted infections, gender-based violence and HIV risk behaviors.

Study procedures

Prior to the start of this trial, we conducted interviews with community informants to enumerate all unique camp-based social networks in operation (n=294) within the study area. In order to be eligible for inclusion in our study, networks had to have more than 20 members, less than 80 members, have been in existence for at least 1 year, and could not have participated in pilot studies with our team. Networks in which research assistants felt unsafe or networks in which a weapon had been used in a fight were also excluded. 172 social networks were eligible and 60 were randomly selected for inclusion in our trial.

Before collecting baseline data, we conducted a census of the selected networks by obtaining current camp rosters. Rosters included each member's first and last name, nickname, gender, birth date, and phone number. We then reached out to each member in selected networks to confirm his or her eligibility and obtain informed consent for enrollment. In order to be eligible, participants had to be older than 15 years of age, have been a camp member for more than 3 months, visit the camp at least once a week, plan on residing in Dar es Salaam for the next 30 months, and be willing to provide contact information for a friend or family member to be used for study tracing purposes. For these reasons, 112 individuals (5.7%) were ineligible and 49 (2.5%) refused to participate. We reached but were unable to schedule appointments with 197 participants (10.1%) and were unable to contact 90 individuals after three attempts (4.6%). A total of 1,500 participants agreed to participate and completed the baseline behavioral assessment between October 8, 2013 and March 23, 2014. Soon after data was collected, camp members from one camp (n=9) requested to be removed from the study because their leader falsified information with regards to the camp's eligibility. This camp was removed from the study, resulting in a final sample of n=1,491 (1,249 men and 242 women) within 59 camp networks. Our overall response rate among potentially eligible participants (n=1,836) was 81.2%. The characteristics of the men included in the study are presented in Table 1.

Behavioral and social network assessment

Trained interviewers conducted the baseline behavioral and social network assessment using tablets programmed with a custom-designed CAPI (computer-assisted personal interviewing) instrument. The network assessment was built into the behavioral assessment tool and displayed the camp roster associated with each participant. Participants were asked whether they knew each camp member. Next, from a list of all known individuals, participants were asked to state whether each of these known members was a friend, acquaintance, or somebody he/she didn't get along with.

Measures

We measured the composition and structure of the networks using the complete dataset, including both men and women. Network size was defined as the number of camp members

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reported on the roster for each camp. Number of responders was defined as the number of members who participated in our baseline assessment. We then computed the response rate within networks.

Compositional characteristics—We computed the percent of male network members, average age of network members, percent of network members that are currently students, percent of network members who had ever been married, and average duration of camp membership within each camp network.

Structural network characteristics—We assessed multiple network measures using all known ties, or relationships, within each network. Number of relationships assessed the total number of known relationships within each camp. We assessed the density of each network by determining the proportion of known ties over all possible ties between network members. Reciprocity of each network was computed as the proportion of mutual ties over all existing ties. Transitivity within each network was computed as the proportion of all closed triplets – three sets of individuals who are all connected to each other - over all possible triplets. Transitivity can be conceptualized as the probability that two network members connected to the same individual are also connected to each other. We computed degree centralization, broadly defined as the difference in degree centrality scores (which assess the total number of incoming and outgoing ties) for the most central node and all other nodes in each camp network (Freeman, 1978). Degree centralization scores range from 0-1 with 1 representing the most centralized network structures (similar to a star shape) and 0 representing the least centralized network structure (with all individuals connected to the same number of network members). Finally, we looked at the entirety of all known ties within each camp and assessed the percent of friendship ties, acquaintance ties, and negative ties within each network. All network metrics were calculated using the igraph software package (Csardi & Nepusz, 2006) in R.

Network normative beliefs—We measured attitudes towards consistent condom use by asking respondents how strongly they agreed with the statement “I should be using condoms all the time.” To assess attitudes towards multiple concurrent partnerships, participants were asked how strongly they agreed with the statement “It’s ok for me to have more than one sexual partner at the same time.” Finally, we measured men’s attitudes towards perpetrating physical intimate partner violence (IPV) by asking participants how strongly they agreed with the statement “There are some situations in which it is ok for me to hit my partner.” Values for the responses to all four of these statements ranged from 1 (strongly agree) to 4 (strongly disagree) and condom use attitudes were reverse coded so that higher scores for all normative beliefs were the most desirable. Additionally, we assessed attitudes towards gender roles with an adapted 15-item version of the inequitable subscale of the Gender Equitable Men (GEM) Scale (Pulerwitz & Barker, 2008). Participants were asked how strongly they agreed with statements such as “it is the man who decides what type of sex to have.” Responses ranged from 1 (strongly agree) to 4 (strongly disagree). Averaging responses to all 15 items per person created an index score for each participant, with 1 representing inequitable norms and 4 representing equitable norms. We then aggregated

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responses for these normative beliefs to the camp level to determine the average network-level normative beliefs characterizing each network.

Network risk behaviors—We asked all participants whether they had ever had sex. Men who reported being sexually active were asked about their age at first sex, their total number of lifetime and past-year sexual partners, as well as their self-reported consistent condom use and sexual partner concurrency. We measured consistent condom use by asking each participant to report condom use over the three most recent sexual partners (number of sexual acts over the most recent month of the relationship and the number of times that a condom was used during this time period for each partner). Using the percent of reported sex acts where condoms were used, participants were categorized as either "consistent condom use" (100% use) or "non-consistent condom use" (less than 100%). Sexual concurrency was evaluated by self-report of any overlapping sexual partnerships for an individual's past three sexual partners. When enumerating current and past sexual relationships, participants were asked 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 within any of the three most recent relationships within the past 12 months were coded as displaying concurrency. Additionally, we assessed past-year intimate partner violence (IPV) perpetration using an adapted version of the World Health Organization violence against women instrument (Garcia-Moreno, Jansen, Ellsberg, Heise, & Watts, 2006). This tool measures psychological, physical, and sexual IPV perpetration. Participants were asked whether they had ever done any of 13 behaviorally specific violent acts to their current partner, or any other partner. For those who said yes to having perpetrated a specific act, they were asked to report the frequency of perpetration in the last 12 months. These responses were then dichotomized such that a 0 represented no violence and a 1 represented at least 1 instance of IPV perpetration within the last year. Alcohol use was assessed by asking participants whether they had ever used alcohol in their lifetime. Finally, participants were asked whether they had ever tested for HIV. All of these responses were aggregated to the camp network level to compute the average network-level risk behaviors.

Analysis

We first used descriptive statistics to assess the composition and structural characteristics of the camp social networks. Next, we used descriptive statistics to assess men's network-level normative beliefs and behaviors. Finally, we obtained estimates of the clustering for all normative beliefs and behaviors by partitioning variance in each of these variables into variance that occurs between camp networks (τ^{00}) and the variance that occurs between men within the same camp (σ^2). We used this information to compute the intraclass correlation (ICC) of each variable by examining the proportion of total variance ($\sigma^2 + \tau^{00}$) that was attributed to the variance between camp networks (τ^{00}) (Snijders & Bosker, 1999). In other words, the ICC represents the average correlation between any two men who belong to the same camp. To obtain estimates of ICCs for continuous variables, we ran a random effects model with maximum likelihood estimation. For binary outcomes, logistic random effects models were used and a proxy for ICC using the variance of the logistic distribution ($\sigma^2 = \pi^2/3$) (Ridout, Demétrio, & Firth, 1999) was obtained. We then tested the significance of the

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group variance (τ^{00}) which is commonly used as a proxy for the significance of the ICC (Raudenbush & Bryk, 2002; Snijders & Bosker, 1999). All analyses were conducted in SAS software Version 9.4 (SAS Institute Inc, 2011).

RESULTS

Network-level compositional and structural characteristics

The social networks had an average of 32.6 members (Table 2), though the smallest network enrolled had 20 members and the largest had 77 members. The mean number of participants who completed our baseline assessment in each camp was 25.3. Specifically, the camp networks had an average of 21.2 male responders and 4.1 female responders. The average camp-level response rate among camp networks was 78.1%.

On average, 84.8% of camp networks were comprised of male members, though one camp had as few as 33.3% male members and other camps (n = 18) had all male members. The mean age of men across networks was 26.0 years, though the youngest camp had an average age of 17.5 years and the oldest camp average age was 38.7 years. On average, 11.3% of camp networks were comprised of current students and just under a quarter of camp network members were married (23.8%). The mean of the camp networks' average duration of membership among camp members was 5.7 years, and this also ranged widely from 1.9 years to 9.5 years.

The social networks contained on average 459.9 known relationships. The camp networks were closely connected, with an average density of 0.43, though network density ranged widely from 0.09 to 0.89. The average reciprocity within camps was 0.43 and ranged from 0.08 - 0.88. For every two members with a mutual friend, there was a 70% chance that they would also be friends (average transitivity = .70). Finally, networks were fairly decentralized with an average degree centralization (a measure assessing the degree to which networks revolve around a single individual) of 0.34.

On average, 74.4% of ties within camps were characterized as friendship ties. There was a camp in which only 26.5% of known ties were considered friendship ties and some camps (n = 2) that were comprised of exclusively friendship ties. On average, 24.6% of ties within camps were characterized as acquaintance ties and less than 1% were negative ties.

Network-level normative beliefs and behaviors

The means of camp network-level attitudes towards condom use and having multiple concurrent sexual partners were 3.4 and 3.3, respectively (Table 3). The means of camp-network level attitudes towards IPV and gender equitable norms were 3.5 and 3.0, respectively.

On average, 89.9% of male network members were sexually active, and this ranged from 61.9% to 100% of male network members being sexually active. The mean of the average age at first sex among sexually active male network members was 17.0. The mean of the average number of lifetime partners among sexually active male network members was 7.6, though in some camps this average number was as low as 2.3 and in others was as high as

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27.2. Within the last 12 months, the mean of the average number of sexual partners was 1.3. On average, 64.6% of sexually active male network members did not use a condom consistently and 19.8% of sexually active males engaged in concurrency. Across camps, an average of 25.1% of male members reported perpetrating IPV within the last year and this ranged from as few as 5% of male members to as much as 47.4% of male members reporting IPV perpetration. An average of 41.7% of male network members had ever consumed alcohol. Finally, an average of 45.7% of male network members had ever tested for HIV and this ranged from a low of only 18.2% of male members having tested to a high of 84.2% of male members having tested.

Clustering of normative beliefs and behaviors

All four normative beliefs were significantly clustered within men's social networks (Table 4). Camp network membership explained 7.21% of the total variance in men's attitudes towards condom use ($\tau^{00} = 0.073$, $p < .001$), 5.79% of the variance in men's attitudes towards multiple concurrent partners ($\tau^{00} = 0.070$, $p = .002$), 6.04% of the variance in men's attitudes towards IPV ($\tau^{00} = 0.052$, $p = .002$), and 6.36% of the variance in men's gender equitable norms ($\tau^{00} = 0.043$, $p = .001$).

Camp network membership explained 15.79% of variance in whether men had ever had sex ($\tau^{00} = 0.62$, $p = .004$). While camp network membership did not explain a significant proportion of variance in age at first sex, network membership did explain a significant proportion of variation in number of lifetime sexual partners (ICC = 2.93, $\tau^{00} = 10.97$, $p = .02$) as well as number of past-year sexual partners (ICC = 1.93, $\tau^{00} = 0.08$, $p = .04$). Camp network membership also explained a significant proportion of variance in consistent condom use (ICC = 5.54, $\tau^{00} = 0.19$, $p = .02$), though it did not account for a significant amount of variation in men's sexual partner concurrency. Men's perpetration of IPV, alcohol use, and HIV testing also clustered significantly within networks. Specifically, network membership explained 3.42% of variance in IPV perpetration ($\tau^{00} = 0.12$, $p = .04$), 10.77% of variance in alcohol use ($\tau^{00} = 0.40$, $p < .001$), and 6.35% of variance in HIV testing ($\tau^{00} = 0.22$, $p = .003$).

DISCUSSION

We set out to describe the structure and composition of the social networks enrolled in an on-going cluster-randomized intervention trial. We found that camp-based social networks in this urban Tanzanian setting varied substantially in composition and structure and that a large degree of male network members engaged in risky behaviors including inconsistent condom use and sexual partner concurrency (64.6% and 19.8% of sexually active male network members, respectively) as well as intimate partner violence perpetration (25.1% of all male network members). There was a wide range of behaviors and normative beliefs when looking across the 59 camp networks enrolled in our trial. For example, while on average approximately 65% of male camp network members did not use condoms consistently, this varied widely from networks in which only 23% of male members reported inconsistent condom use to networks in which over 87% of male members reported inconsistent condom use.

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We found significant clustering of multiple normative beliefs and risk behaviors among men. Specifically, all four normative beliefs were significantly clustered within men's camp-based peer networks. Camp network membership explained between 5.78 and 7.17% of the total variance for men's normative beliefs with attitudes towards condom use displaying the most clustering within camp networks. Risk behaviors were also significantly clustered for men with ever having sex, alcohol use, and HIV testing displaying the highest ICCs (15.79, 10.77, and 6.35%, respectively). This means that men with the same behaviors tend to socialize in the same camp networks and that networks tends to be more internally homogeneous and externally heterogeneous with regard to multiple HIV-related behaviors than would be expected by chance.

Our findings are comparable to other studies that have examined clustering of HIV-related norms and behaviors in other settings. For example, significant clustering of norms related to HIV risk behaviors and sharing of injection equipment was examined in a study conducted with networks of injecting drug users (IDUs) in the US and Thailand (Latkin et al., 2009). This study concluded that social networks should be targeted by interventions seeking sustained behavior change. Another study of HIV risk behaviors among social networks of young MSM in Russia also found significant levels of clustering of risk behaviors and social networks were a strong predictor of behaviors and STDs (Amirkhanian et al., 2006). In this study, we documented clustering of multiple norms and various behaviors across more heterogeneous naturally occurring peer social networks. In contrast to the studies of IDUs and MSM, which are likely characterized by a more universal underlying risk, the networks included in this study were not defined by a unifying behavior (e.g. injection drug use), and thus clustering within groups may be even more likely.

Interestingly, we found that normative beliefs surrounding behaviors clustered more than the actual behaviors in each case where we assessed both normative beliefs and actual behaviors. Camp membership accounted for 7.21% of variance in men's normative beliefs towards condom use and 5.54% of men's self-reported consistent condom use. We believe these patterns of clustering suggest that social networks may be influencing the normative beliefs and behaviors of male network members (i.e. social influence). However, it is also possible that men are selecting to be in networks with peers that hold similar values and engage in similar behaviors (i.e. social selection or homophily) (McPherson et al., 2001). Additionally, it is possible that men are primarily driven to socialize with men with other similar demographic characteristics (e.g. same age, education, or marital status) and those men happen to share similar values and behaviors. Regardless, we believe these findings highlight the importance of peer networks in either influencing or reinforcing the attitudes and behaviors of young men. Taken together, these findings highlight the need for additional research in this context to inform the development of multi-level interventions that target men's social networks. We outline specific areas of future research below.

Additional research on selection vs. influence

We found significant clustering of men's normative beliefs and risk behaviors using cross-sectional data, suggesting social networks may be important socialization sites for young men and may influence the adoption of norms and behaviors. However, since clustering may

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arise as a result of selection or homophily effects as opposed to (or in addition to) social influence, our understanding of the mechanisms contributing to the clustering of behaviors and normative beliefs would be improved with longitudinal research. Specifically, we need longitudinal research on evolving social ties as well as temporal indicators of behaviors and normative beliefs to better understand how normative beliefs and behaviors change over time within dynamic social networks in sub-Saharan Africa. This type of data will allow for the empirical examination and separation of selection from influence effects because we would have the ability to determine whether friendship ties are formed before or after behaviors between friends become similar (Kandel, 1978; Steglich, Snijders, & Pearson, 2010). Such research will provide important information towards the development of interventions designed to maximize social influence effects within peer networks.

Explanatory models of risk behaviors

We also found high rates of numerous risky behaviors including inconsistent condom, sexual partner concurrency, and intimate partner violence perpetration. Additionally, an average of only 45% of network members had tested for HIV. Scholars are becoming increasingly aware that men's risk behaviors and beliefs are shaped by factors at multiple levels of influence and intervening effectively requires an understanding of these multilevel influences (Kaufman et al., 2014). Future research could test explanatory models of these risk behaviors that examine both individual and network-level characteristics as predictors of risk in multilevel analyses. For example, studies are needed that examine the relationship between peer network descriptive and injunctive norms and various risk behaviors. Descriptive norms reflect what is done with a peer group with regard to a behavior and injunctive norms reflect the appropriateness of a behavior or what a peer group thinks ought to be done with regard to that behavior (Cialdini et al., 1990). Social learning theory suggests that men's behavior is likely influenced by their perceptions of the behaviors of their peers as well as their perception of their peer's values around the behavior (Bandura, 1977). Additionally, the theory of normative social behavior suggests that the relationship between descriptive norms and behaviors is moderated by injunctive norms (Rimal & Real, 2005). To our knowledge, these mechanisms have never been tested among youth in sub-Saharan Africa and could have implications for social norm-based interventions. Specifically, understanding the ways in which various types of norms influence the behaviors of individuals will help us understand what types of norms should be targeted to most effectively, and possibly synergistically, influence HIV risk behaviors. This is particularly important since the lack of attention to norms may help explain why most interventions to prevent HIV among youth in sub-Saharan Africa have been ineffective (Michielsen et al., 2010).

Research on influence of network structures

In this study, we documented a wide range of structural characteristics within camp networks. The structural theory of social influence suggests that network structures may shape opportunities for normative influence (Friedkin, 2006). More specifically, structural characteristics, including network size, density, transitivity, and centralization, may facilitate or constrain the likelihood that social norms influence the behaviors of members. More connected networks – those with greater density, for example - may allow for more rapid

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diffusion of health information or normative beliefs between individuals (Valente & Fosados, 2006). Additionally, groups with greater transitivity – those where a higher proportion of friends who are friends with each other's friends –may also be characterized by more frequent discussions about health behaviors and the consequences of those behaviors (Burt, 1987). Consequently, higher levels of density or transitivity may increase the likelihood that individuals perceive and embrace normative information surrounding specific health behaviors. Future research should examine the extent to which structural characteristics like network density and transitivity moderate the relationship between network norms and behaviors. Understanding these relationships could inform intervention efforts that simultaneously transform important norms while leveraging and potentially enhancing network structures.

Additionally, groups with individuals who hold more central positions compared to others within the networks – those with higher levels of centralization - may be more effective in exerting social control over deviant behavior (Sampson & Groves, 1989). As a result, the centralization of networks may also moderate the relationship between injunctive norms of network members and behaviors. The role of network centralization in shaping the social control of network members should also be examined in future research. These findings could further support and inform the development of interventions that aim to leverage specific aspects of normative power of individuals who hold special roles within their networks (Schneider, Zhou, & Laumann, 2015).

Role of network structure on intervention effects

Given the wide range of stuctural properties found within these naturally-occuring camp-based social networks, we believe future research should examine whether network structures directly or indirectly influence the effectiveness of interventions on behavior change. Network-based interventions have great potential to change norms that can then be socially reinforced among peers (Latkin & Knowlton, 2005). It will be important to understand whether such interventions are more or less effective in networks that are more closely tied to one another. Network-based interventions also provide an opportunity to engage popular individuals who play central roles in their networks to advise other network members in ways to reduce their risky behaviors (Valente & Pumpuang, 2007). Future lines of research may want to examine whether the effectiveness of such opinion leaders is mediated or moderated by their position within their social networks. Finally, there is little research on how networks change over time and studies examining how networks evolve could be fruitful (Latkin & Knowlton, 2015). As recommended by Latkin and Knowlton (2015), future research could also examine the relevant merit of interventions that try to change ties (by either advising participants to break social ties or forming new ties) compared to improving the characteristics of existing ties.

Strengths and limitations

A key strength of this study is the use of multilevel modeling to compute intraclass correlations of multiple HIV-related behaviors and beliefs that may be targeted by future interventions. Power and sample size calculations for network-based intervention trials

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require estimates of ICCs, which are currently lacking in the literature (Gao, Earnest, Matchar, Campbell, & Machin, 2015).

Our study is not without limitations. First of all, we relied on self-report to assess normative beliefs and behaviors and as a result, our measures may be affected by inaccurate reporting as well as recall bias and social desirability bias. Additionally, while all of the normative beliefs and several behaviors were assessed continuously, several behaviors were dichotomous in nature, thus the ICC estimates obtained are on a logistic scale and not directly comparable. It is also important to note that our data come from men nested within camp-based peer networks in Dar es Salaam, and as such, may not be generalizable to other social networks of youth in urban sub-Saharan African settings. We also excluded camps that were the most unsafe and recognize that these camps may have contributed data that could have shaped the results presented. Specifically, since men in more violent camps may have been more likely to engage in other risky behaviors, excluding these camps likely decreased the variability of norms and behaviors reported, leading to conservative estimates of the clustering across the networks. Also, while we made multiple attempts to contact and enroll all members of these camp-based networks, we were only able to obtain behavioral and social network data from an average of 78.1% of network members. While over a quarter of our networks had response rates over 90%, only 2 networks provided complete data and the low response rate in some camps is not ideal for studies using sociocentric network properties. Missing data is important to studies of social networks (Kossinets, 2006) and may have shaped the structural properties of the networks described in this study. Future studies examining effects of network structure may need to be restricted to networks with greater than 50% response rate, as has been done in previous studies (McFarland, Moody, Diehl, Smith, & Thomas, 2014), and may need to consider the best methods to impute missing network ties (Huisman, 2009). Fortunately, by having each participant identify all individuals known to him/her in their camp network, and not limiting participants to identifying up to a fixed number of friends, our data are not biased by the fixed choice effect (Kossinets, 2006). Moreover, we are not able to separate social selection from social influence in understanding why normative beliefs and behaviors may be clustering within peer networks.

CONCLUSION

We documented significant clustering of men’s HIV-related normative beliefs and behaviors within their naturally occurring peer social networks in an urban Tanzanian setting. These findings suggest that networks are important contexts for shaping or reinforcing men’s risk behaviors as well as protective behaviors like HIV testing in sub-Saharan Africa. Future research should assess to the degree to which selection and influence effects lead to clustering of behaviors and beliefs, test explanatory models of risk behaviors that examine both individual and network-level characteristics as predictors of risk, and evaluate the influence of network structures on risk behaviors. This information can ultimately inform the development of innovative, sustainable, and empirically based multi-level interventions that are needed to effectively prevent HIV.

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RESEARCH HIGHLIGHTS

- Social network analysis and multilevel modeling to describe a unique dataset
- Networks vary substantially in composition and structure
- Large proportions of men's social networks engaged in risky behaviors
- Significant clustering of men's HIV risk behaviors and normative beliefs
- Network-based research needed regarding men's risk behaviors in Sub-Saharan Africa

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Table 1

Characteristics of men (n=1,249) in sample

Variables	Mean (range) or % (n)
Age in years	26.1 (15-59)
15-19	18.7 (233)
20-24	29.9 (374)
25-29	26.4 (330)
30+	25.0 (312)
Currently a student	10.6 (132)
Education	
Primary school or less	56.6 (707)
Some secondary school	11.8 (147)
Secondary school completed or more	31.3 (391)
Previously married	22.3 (278)
Duration of camp membership in years	6.0 (.25 – 36)
Ever had sex	89.1 (1113)
Age at first sex [a]	17.1 (7 – 30)
Number of lifetime sex partners [a]	7.6 (1 – 300)
Number of past-year sex partners [a]	1.3 (0 – 50)
Inconsistently used a condom with past three partners [a]	56.1 (624)
Engaged in concurrency within last year [a]	17.3 (195)
Perpetrated IPV within last year	25.1 (314)
Ever used alcohol	41.0 (512)
Ever tested for HIV	45.7 (571)

[a] Among sexually active members

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Table 2

Network-level compositional and structural characteristics (n=59)

Characteristic	Mean	SD	Range
Networks size	32.6	12.4	20 – 77
Number of responders	25.3	10.8	7 – 66
Number male responders	21.2	8.9	7 – 40
Number female responders	4.1	4.9	0 – 26
Response rate within networks	78.1	17.8	25 – 100
Compositional characteristics			
% male network members	84.8	15.3	33.3 - 100
Avg. age of network members	26.0	4.4	17.5 - 38.7
% network members that are currently students	11.3	11.5	0 - 40.7
% camp members who have ever been married	23.8	19.1	0 - 88.9
Avg. duration of camp membership in years	5.7	1.9	1.9 - 9.5
Structural network characteristics			
Number of ties (known relationships)	459.9	376.3	71.0 – 1722.0
Density	0.43	0.20	0.09 - 0.89
Reciprocity	0.43	0.19	0.08 - 0.88
Transitivity	0.70	0.19	0.20 - 0.99
Degree centralization	0.34	0.10	0.06 - 0.50
% friendship ties	74.4	21.8	26.5 - 100
% acquaintance ties	24.6	21.1	0 - 73.5
% negative ties	0.8	1.4	0 - 5.3

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Table 3

Network-level normative beliefs and risk behaviors among men (n = 1,249) within networks (n = 59 camps)

Network normative beliefs (range 1-4)	Mean	Std. Dev.	Range
Avg. condom use attitudes	3.4	0.4	2.2 – 4.0
Avg. attitudes towards multiple concurrent partners	3.3	0.4	2.4 – 4.0
Avg. attitudes towards IPV	3.5	0.3	2.6 – 4.0
Avg. gender equitable norms	3.0	0.3	2.3 - 3.6
Network risk behaviors			
% sexually active network members	89.8	9.8	61.9 - 100
Avg. age at first sex [a]	17.0	0.8	14.9 - 19.1
Avg. number of lifetime sex partners [a]	7.6	5.8	2.3 - 27.2
Avg. number of past-year sex partners [a]	1.3	0.4	0.7 - 2.9
% not consistently using a condom [a]	64.6	16	23.1 - 87.5
% who engage in concurrency	19.8	13.4	0 – 80.0
% who perpetrated IPV within last year	25.1	11.2	5 - 47.4
% who have ever consumed alcohol	41.7	17.8	4.2 - 84.6
% who have ever tested for HIV	45.7	16.3	18.2 - 84.2

[a] Among sexually active members

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Table 4

Intraclass correlations of norms and risk behaviors among men (n = 1,249) within networks (n = 59 camps)

Normative Beliefs	
Attitudes towards condom use	7.21***
Attitudes towards multiple concurrent partner	5.79**
Attitudes towards IPV	6.04**
Gender equitable norms	6.36**
Risk Behaviors	
Sex ever [a]	15.79**
Age at first sex	2.38
Number of lifetime sex partners	2.93*
Number of past-year sex partners	1.93*
Consistent condom use [a]	5.54*
Concurrency [a]	2.57
IPV perpetration – any [a]	3.42*
Alcohol use [a]	10.77***
HIV testing [a]	6.35**

*** p<.001,

** p<.01,

* p<.05

[a] Dichotomous outcomes with ICCs on logistic scale