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Social networks moderate the syndemic effect of psychosocial and structural factors on HIV risk among young Black transgender women and men who have sex with men.

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Abstract

The interaction between the cumulative effect of psychosocial and structural factors (i.e. syndemic effect) and social networks among young Black transgender women and men who have sex with men (YBTM) remains understudied. A representative cohort of 16–29 year-old YBTM (n=618) was assessed for syndemic factors [i.e. substance use; community violence; depression; poverty; justice system involvement (JSI)], social network characteristics, condomless anal sex (CAS), group sex (GS), and HIV-infection. The syndemic index significantly increased the odds of CAS, GS, and HIV-infection, and these effects were moderated by network characteristics. Network JSI buffered the effect on CAS, romantic network members buffered the effect on GS, and network age and proportion of family network members buffered the effect on HIV-infection. The proportion of friend network members augmented the effect on GS and HIV-infection. Future research to prevent HIV among YBTM should consider social network approaches that target both structural and psychosocial syndemic factors.

Keywords

Black; Transgender Women; MSM; HIV; Syndemic

INTRODUCTION

Young Black transgender women and men who have sex with men (YBTM) bear an increasingly disproportionate burden of new HIV infections in the United States (US).(1–5) Between 2008 and 2014, HIV prevalence among young Black men who has sex with men (YBMSM) across 20 American cities increased from 17% to 26%.(6) Black transgender women also are one of the most vulnerable populations to become HIV positive in the US,

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with an estimated HIV prevalence of 56%.(7) However, compared to other men who have sex with men (MSM), Black MSM (BMSM) are more likely to use condoms during anal sex and less likely to use drugs during sex.(8) Thus, the excessive burden of HIV infection among YBTM is not likely explained solely by individual behavior and may be better explained by psychosocial (i.e., indicators of psychological and social functioning, such as depression, anxiety, substance abuse) and structural factors (e.g., poverty, justice system involvement, unemployment).(3, 8–16) In addition, a growing body of evidence suggests that social network factors (i.e., the number of people in a social network and the characteristics of different network members) may significantly influence vulnerability to HIV infection among YBTM.(17–20) Research on how social network characteristics moderate the relationship between psychosocial and structural factors and HIV transmission-related behaviors and HIV serostatus among YBTM is limited.

Syndemic Theory

Syndemic theory offers an approach to investigate inequities in HIV incidence within a psychosocial and structural framework that remains understudied among YBTM.(13, 21) A syndemic is defined as co-occurring, mutually enhancing epidemic psychosocial factors that exacerbate illness and reinforce health inequities.(22–24) Merrill Singer first described a syndemic of substance abuse, violence and AIDS (SAVA) in a poor urban setting.(23) Stall et al. extended syndemic theory to describe increased vulnerability to HIV/AIDS among MSM by including psychosocial factors such as depression, childhood sex abuse and partner violence.(22) Further studies have established significant associations between syndemic factors and HIV transmission-related behaviors among young MSM.(25–27) However, applying the MSM syndemic framework to BMSM populations have produced mixed results,(21, 26, 28, 29) which may be because studies rarely incorporate structural factors that are most relevant to BMSM.(13)

As syndemic research has progressed, scholars have highlighted how social and structural factors such as sex work, gender-based violence, and poverty create unique contexts of hyper-vulnerability to HIV among cisgender women.(30–32) Similarly, research examining syndemic conditions among transgender women has demonstrated that syndemics are positively associated with both transactional sex and incarceration.(14, 33) However, prior syndemic research focused on HIV often does not consider structural factors that disproportionately affect YBTM, such as incarceration, poverty and community violence, which may contribute to higher burden of HIV incidence among YBTM.(12–14, 33–41) In two exceptions, Wilson et al. proposed that poverty, incarceration and community violence likely synergistically contribute to increased HIV risk among Black men,(13) and Mizuno et al. included incarceration and homelessness in a syndemic index among people with injection drug use living with HIV.(42)

The analytic approach employed by Wilson et al.(13) and Mizuno et al.(42) is consistent with more recent interpretations of syndemic theory, which focus on both the synergistic clustering of health inequities and social conditions that perpetuate, maintain, and exacerbate health inequities. Including poverty, community violence, incarceration and other indicators of unequal social conditions in syndemic analyses is important given that these factors are

disproportionately experienced by Black cisgender and transgender men and women, and tend to have a synergistic impact on health.(13) Poverty, incarceration, and community violence affect Black communities in epidemic proportions. In 2010, the US Census estimated that Black Americans represented 24.2% of people living in poverty, while making up 12.3% of the US population, and that 50.4% of Black Americans lived in areas of concentrated poverty.(43) Also in 2010, Black men and women represented 38.9% of the U.S. prison population, and experienced an imprisonment rate 6.5 times greater than White men and women.(44) From 2009 to 2016, the age-adjusted rates of homicide among 15–29 year old non-Hispanic Black men increased 55.00 to 73.38 per 100,000, whereas the age-adjusted rates of homicide among 15–29 year old non-Hispanic White men remained stable at 3.36 to 4.09 per 100,000 over the same time period.(45) Beyond homicide, from 2015 to 2016 the rate of criminal victimization in urban settings increased from 22.7 to 28.4 per 1,000 people, and victims were more likely to be Black and low-income.(46) A national survey of urban adolescents found that 55% had been exposed to community violence, which was further concentrated among Black adolescents and positively associated with symptoms of posttraumatic stress disorder.(47) Previous research also has found that exposure to community violence is associated with significantly higher rates of HIV-related transmission behaviors among YBMSM.(37, 48, 49) Importantly, poverty and incarceration are interlinked and independently associated with substance abuse and risk of HIV infection. (34, 36, 50–52) Specifically, housing instability has been associated with justice system involvement(17) and HIV transmission among YBMSM.(53) In addition, poverty and incarceration are two of the leading predictors of HIV infections among YBMSM in the US, (8) and are further concentrated among Black transgender women.(8, 54, 55) Given these data, it is imperative to consider structural factors such as poverty, incarceration and community violence within a syndemic framework in order to understand inequitable vulnerability to HIV infection among YBTM.

Stress, Resilience and Social Networks

Minority stress theory suggests that stigma and discrimination are primary determinants of poor health and mental health among sexual and gender minority (SGM) populations.(56–58) Research investigating minority stress among populations with multiple minority statuses, such as racial, sexual and gender minorities, suggests that discrimination and stigma experienced by YBTM are likely to be unique and different from single minority populations.(59–62) The stress-buffering hypothesis in minority stress theory suggests that resiliency factors, such as social support, community connectedness, and pro-social coping may buffer against minority stressors.(28, 63) As research on the health of SGM populations has grown, several researchers have noted the need for resilience-focused research with MSM and transgender women. For example, Herrick, et al.(64) proposed a resilience framework for prevention research among MSM that identified potential resilience factors at the individual, dyadic, family, and community levels. In addition, Herrick and colleagues recommend that future research utilize moderation analyses, exploring factors such as social support, as a method of testing causal pathways.(64) In one of the few syndemic studies to test the moderating effect of resilience factors, O'Leary et al. found that both optimism and educational status buffered the effect of syndemic conditions on HIV serostatus in a sample of BMSM.(28) More recently, Pitpitan et al. demonstrated "outness" as a buffer of syndemic

conditions on HIV risk-taking behavior among MSM in Tijuana, Mexico.(65) However, there is a dearth of research on the moderating effects of social networks on syndemic conditions.

The lack of research on how social networks may exacerbate or buffer the effect of syndemic conditions on HIV among YBTM is surprising given the large body of scholarship implicating social networks in vulnerability to HIV.(18, 66–72) For example, among BMSM, supportive networks have been associated with a lower likelihood of HIV infection(68) and condomless anal sex(69), and a higher likelihood of HIV testing.(69, 70) In addition, studies suggest that the types of nodes in an ego's network, e.g., the proportion that is family of origin, family of choice, friends, and sexual partners, are related to HIV transmission-related behaviors and HIV serostatus.(67) Furthermore, in our prior work, we found that the proportion of family members in the social networks of YBMSM was associated with less sex-drug use and group sex, and with a higher likelihood of discouraging group sex and sex-drug use.(18) Conversely, negative peer norms about safer sex may lead to riskier sex behaviors,(73, 74) and lack of social support may mediate sex work among Black men.(72) The presence of "enablers", network members who do not disapprove of engaging in risk behaviors, within a social network may increase the likelihood of condomless anal sex among Black MSM.(71) In addition, network HIV viral load has been demonstrated to be associated with increased HIV seroprevalence among YBTM.(75) Beyond HIV transmission risk factors, social network characteristics also have been closely tied to psychosocial and structural factors such as housing,(76) substance abuse,(72) and incarceration.(17)

The Present Study

The current study examines the syndemic effect of both psychosocial and structural factors on HIV transmission-related behaviors and HIV infection, and the potential moderating effect of social network factors in a representative sample of YBTM. The study has several aims. First, we aimed to characterize a syndemic index of psychosocial and structural factors that are relevant to YBTM and that significantly impact HIV infection and HIV transmission-related behaviors, i.e., condomless anal sex and group sex. Our second objective was to investigate social network characteristics as potential moderators of the association between the syndemic index and our three HIV-related outcomes of interest. Because prior research has found that YBTM tend to be embedded in homophilous social networks, it is plausible that network members are also subjected to syndemic conditions that can affect vulnerability to HIV among YBTM.(17, 71) To test this possibility and further extend the research base on syndemic conditions and social networks, we created and examined the moderating effect of a network syndemic indicator. Lastly, we sought to replicate findings by O'Leary et al.(28) by testing if respondents' education moderated the association between the syndemic index and HIV-related outcomes.

Based on the extant research, we hypothesized that community violence, poverty, history of justice system involvement (JSI), illicit substance use (ISU) and depression would be significantly mutually enhancing, supporting their inclusion in the syndemic index. We next hypothesized that a syndemic index consisting of psychosocial and structural factors would

be associated with a higher odds of HIV infection and HIV transmission-related behaviors among YBTM. We hypothesized that larger social networks, and networks including more members who are friends, family, male or older, would buffer the effect of syndemic index on HIV-related outcomes. Conversely, we anticipated that social networks with more members with JSI, ISU, or who are romantic or HIV seropositive would exacerbate the effect of the syndemic index on HIV-related outcomes. In addition, we hypothesized that the number of syndemic factors within social networks would exacerbate the effect of the syndemic index on HIV-related outcomes. Finally, we expected that higher educational achievement among index respondents would operate as a protective factor and buffer YBTM against the negative effects of syndemic factors.

METHODS

Setting and population

We analyzed baseline data from the uConnect study, a longitudinal population-based cohort of YBTM in Chicago that aims to examine how social and sexual networks impact the risk of sexually transmitted infections among YBTM, including HIV. Chicago is home to one of the largest contiguous geographic communities of Black American residents in the United States.(77) The role of violence is particularly salient in cities like Chicago, which have a long history of racial segregation and disinvestment in majority Black American neighborhoods; in Chicago, this has contributed to place-based poverty and community violence on the South and West Sides of the city.(78, 79)

Study participants

Eligibility criteria—Study respondents were eligible if they 1) self-identified as Black or African American, 2) were assigned male sex at birth and currently identify as a male or as a transgender woman, 3) were 16 to 29 years old, 4) reported oral or anal sex with a male within the past 24 months, 5) were residing on the South Side of Chicago, and 6) were willing and able to provide informed consent.

Recruitment and Data Collection—Recruitment and data collection procedures for the uConnect study have been previously described.(17, 19, 71) Briefly, respondent driven sampling (RDS) was used to recruit a diverse group of YBTM between June 2013 and June 2014. A total of 62 seeds were recruited via various venues (i.e. House/Ball community, Facebook, community events, college campuses, etc.) and invited to recruit other eligible YBTM. Participants were offered $60 for completing the interview and $20 for each additional recruit. Interviews were conducted using Computer Aided Personal Interviewing.

Measures

Outcomes.—HIV infection was determined by 4th generation HIV immunoassay (Abbott ARCHITECT HIV Ag/Ab Combo assay), HIV-1/−2 Ab differentiation (Bio-Rad Multispot HIV-1/−2 Rapid Test). Condomless sex with male or transgender partner(s) in the last 6 months (CAS), and group sex in the past 12 months (GS) were self-reported (0 = no, 1 = yes).

Psychosocial and structural syndemic factors.—Psychosocial and structural syndemic factors were self-reported and included: 1) illicit substance use (ISU), 2) depression, 3) lifetime history of being a victim of community violence, 4) justice system involvement (JSI) and 5) poverty. ISU was assessed as using ecstasy, volatile nitrates, cocaine/crack, heroin, psychedelics or methamphetamines in the past 12 months (marijuana and alcohol were not included). Depressive symptoms were determined using the Brief Symptom Inventory-18 depression subscale T-score; participants with a T-score > 62 were considered to have depression.(80) Community violence was assessed using the Community Violence Probe,(81) a questionnaire previously validated with young Black men(17, 37, 82) that evaluates the number of times (range: 0 to ≥ 6) respondents experience violence, witness violence, and have friends and family who are victims of violence (Cronbach's alpha = 0.88). Following previous studies,(17, 37) we calculated raw scores by taking the means of all the item scores and then converted the raw scores to T-scores. Respondents with a T-score greater than or equal to the median were considered to have a lifetime history of community violence. JSI was assessed by asking participants, "Have you ever been detained, arrested, or spent time in jail or prison?" (0 = no, 1 = yes). Similar to a measure of poverty developed by Mena et al. that was previously associated with HIV risk among YBMSM,(50) poverty was defined as not having enough money in the household for rent, food, or utilities in the last 6 months or being homeless in the past 12 months. The syndemic index (range: 0 to ≥ 4) was calculated for each respondent by summing the presence of 5 psychosocial and structural factors: ISU, depression, history of community violence, poverty and JSI.

Social network characteristics.—Participants listed up to 5 members of their close and personal social network, defined as "people with whom you discuss things that are important to you." After populating their network, each participant described the type of relationship, age, gender, HIV serostatus, JSI and ISU of each network member. Type of relationship was categorized as friend, romantic (i.e. spouse, current or ex-romantic partner, or non-romantic sex partner), family (i.e. play, made-up, by blood, or by marriage), or other (i.e. co-worker, neighbor, housemate, minister, teacher, doctor, or counselor). Participants also reported the HIV serostatus of each network member, how often a network member used illicit substances (0 = never or less than once a year, 1 = at least once a year), and whether they had ever been detained, arrested, or spent time in jail/prison (0 = no, 1 = yes). Older social network member age was defined as being at least 1 year older than respondents (0 = no, 1 = yes), and peer social network members was defined as aged within 1 year (older or younger) of respondents (0 = no, 1 = yes). Similar to previous studies, we calculated the proportion and number of network members with each characteristic within each respondent's social network.(71, 83) In addition, we calculated a social network syndemic index by summing the presence of ISU and JSI within each respondent's social network (0 = no presence of social network ISU or JSI; 1 = presence of social network ISU or JSI; 2 = presence of social network ISU and JSI).

Social-demographic factors.—Respondents reported their age, sexual orientation, transgender identity, educational achievement, employment status and healthcare coverage. For respondents who were HIV seropositive we calculated days since HIV diagnosis, and for

respondents with JSI we calculated total days spent in the justice system. Transgender identity was determined using the two-step method described by Reisner, et al.(84)

Analysis

All analyses were performed using R Statistical Software (R Version 3.5.2). Exploratory analyses indicated that some variables had missing data at up to 3.6%. We used the Survey Package in R to conduct logistic regression, and treated missingness by list-wise deletion. (85) Logistic regression models were weighted using Gile's sequential sampling estimator, which treats RDS as a successive sampling process of a known or reliably estimated population.(86) In the present study, we used Livak et al.'s estimation that there are 5,500 YBMSM in the catchment area.(87) Following syndemic theory, in order to examine if psychosocial and structural factors were mutually enhancing, we conducted a series of bivariate logistic regressions between each syndemic factor. We also conducted bivariate logistic regression between psychosocial and structural factors and outcomes of interest. In order to test for a cumulative syndemic effect, we next completed binomial multivariate logistic regression with the syndemic index as the independent variable and CAS, GS or HIV infection as a dependent variable. Because HIV diagnosis(76) and JSI (17, 19, 37) have been shown to impact social networks of YBMSM, we included time since HIV diagnosis and time spent in the justice system in days in our modeling. Age, HIV serostatus, time since HIV diagnosis and time spent in the justice system were included *a priori* in modeling of behavioral outcomes. Age and time spent in the justice system were included *a priori* in modeling of HIV infection. Covariates included in modeling were education, employment status, sexual orientation, transgender identity and health care insurance status. Goodness-of-fit was assessed using Akaike Information Criterion (AIC), and models with lower values indicated better fit.(88)

To examine if social networks characteristics moderated the association between the syndemic index and the dependent variables, we used methods described by Baron and Kenny.(89) We tested the significance of interactions between the syndemic index and social network characteristics (size, age, gender, relationship, ISU, JSI, and social network syndemic index), as well as respondent education, for each outcome. Social network variables included two dichotomous variables, $\geq 50\%$ vs. $< 50\%$ of network with a given characteristic and ≥ 1 member vs. none with a given characteristic. We created probability plots and calculated adjusted odds ratios stratified by social network characteristics with significant moderator effects. We tested for multicollinearity using variance inflation factor (VIF) analysis with a threshold value of 10.(90) When VIF score exceeded 10, we centered the syndemic index to determine if there was a difference. Finally, we conducted a sensitivity analysis with unweighted models.

RESULTS

Descriptive characteristics.

Socio-demographic, psychosocial and structural factors of the 618 respondents included in the study population are described in Table 1. Transgender women comprised 9% of the sample. The median age was 23 [interquartile range (IQR) 20, 25] and most respondents

(66%) identified as gay. The median number of social network members was 2 (IQR 2, 3). More than half of the study population (61%) had achieved education beyond high school, 48% were unemployed and 46% did not have healthcare coverage. Structural syndemic factors were prevalent: 51% reported a history of community violence, 46% reported justice system involvement (JSI) and 53% reported poverty. Psychosocial syndemic factors, such as depression (12%) and illicit substance use (ISU) (18%), were less prevalent. Community Violence Probe measures demonstrated that 65% reported being a victim of violence, 83% reported having a close friend robbed or attacked, 71% witnessed someone being beaten and 57% witnessed gun related violence. Most study participants (84%) reported at least 1 syndemic factor, and 57% reported 2 or more syndemic factors. There also was a high prevalence of HIV infection, with 34% being HIV seropositive. In addition, 21% reported group sex (GS) and 48% reported condomless anal sex (CAS).

Respondents reported the characteristics of 1566 social network members (see Table 2). Social networks consisted mostly of friends and family who were male and older, with a median age of 27 (IQR 22.75, 33.42). Among respondents, 80% had ≥ 1 older member, 61% had ≥ 1 peer member, 81% had ≥ 1 male member, 68% had ≥ 1 friend, 59% had ≥ 1 family member, and 32% had ≥ 1 romantic member. Social network ISU was not common, with 12% of respondents with ≥ 1 member with ISU; however, 49% of respondents had ≥ 1network member with JSI and 21% had ≥ 1 HIV-positive network member.

Syndemic conditions.

Bivariate association in-between psychosocial and structural factors, and between those factors and outcomes are described in Table 3. The adjusted odds ratio of the syndemic index on HIV infection and HIV-related transmission behaviors are shown in table 4. Consistent with our hypothesis, the syndemic index was significantly associated with an increased odds of HIV infection [adjusted odds ratio (aOR) = 1.31, 95% confidence interval (95% CI) 1.08–1.60, $p < 0.01$], GS (aOR 1.28, 95% CI 1.00–1.63, $p = 0.04$) and CAS (aOR 1.31, 95% CI 1.09–1.57, $p < 0.001$), when controlling for confounding factors.

Moderator results.

Significant moderation effects by social network characteristics are shown in Table 4. As hypothesized, the syndemic effect on HIV infection was buffered by social networks that consisted of more family members (< 50% vs. ≥ 50% aOR 0.64, 95% CI 0.43–0.96, $p = 0.03$, Figure 1B) and social networks with ≥ 1 older members (aOR 0.60, 95% CI 0.38–0.96, $p = 0.03$; Figure 1C). Contrary to our hypothesis, we found that the syndemic effect on HIV infection was augmented by social networks with a greater proportion of friends (< 50% vs ≥ 50% aOR 1.66, 95% CI 1.13–2.43, $p < 0.01$, Figure 1A).

We also found a significant interaction between the syndemic index and social network characteristics on HIV transmission-related behaviors. Contrary to our hypothesis, the syndemic effect on GS increased among respondents with more friends in their social network (0 vs ≥ 1 aOR 1.80, 95% CI 1.11–2.93, $p = 0.01$, Figure 1E; < 50% vs ≥ 50% aOR 1.64, 95% CI 1.04–2.57, $p = 0.03$), and buffered among respondents with more romantic network members (0 vs ≥ 1 aOR 0.64, 95% CI 0.41–1.00, $p = 0.05$, Figure 1F). Also,

unexpectedly, the syndemic effect on CAS was buffered by having more social network members with JSI (0 vs $\geq$ 1 aOR 0.67, 95% CI 0.47–0.96, p = 0.05, Figure 1D). The social network syndemic index had a significant buffering effect on the relationship between the respondent syndemic index and CAS (aOR 0.71, 95% CI 0.54–0.94, p = 0.02). We did not find any significant interactions between the syndemic index and social network size, ISU or HIV status. Lastly, respondent education did not moderate the effect of the syndemic index on HIV-related outcomes.

Sensitivity analyses.

Centering the syndemic index did not change results, and the unweighted analysis demonstrated significant bivariate and multivariate results (see Supplemental Tables I and II). The unweighted models demonstrated significant increase in the association between syndemic index and HIV infection among respondents with more transgender network members (0 vs $\geq$ 1 aOR 2.01, 95% CI 1.02–3.96, p = 0.04; < 50% vs $\geq$ 50% aOR 8.09, 95% CI 1.43–45.87, p = 0.02). Also, in the unweighted models, there was no significant moderation of the association between syndemic index and GS or CAS.

DISCUSSION

This study investigated the relationship between syndemic factors and social networks on HIV serostatus and HIV-related transmission behaviors among YBTM. A syndemic index inclusive of psychosocial and structural factors relevant to YBTM was significantly associated with an increased odds of HIV infection, engaging in group sex in the past 12 months (GS), and reporting condomless anal sex in the past 6 months (CAS). Moderation analysis demonstrated that various social network characteristics, including age, gender, justice system involvement (JSI), number of friends, number of romantic members and family proportion, significantly moderated the syndemic effect on HIV infection and behavioral outcomes. Overall, psychosocial, structural and social network factors contribute to significant variability in HIV-related outcomes in this study population. This study advances the understanding of the interplay between social networks and syndemic psychosocial and structural factors among YBTM and can inform future research and HIV prevention efforts.

For every additional syndemic factor there was a 31% increased odds of HIV infection, 31% increased odds of CAS and 28% increased odds of GS. Whereas previous syndemic studies among YBTM have limited syndemic indices to psychosocial factors, such as mental health, substance abuse and childhood or sexual violence,(22, 25, 26) this study included incarceration, poverty and community violence, which are structural factors that disproportionately affect YBTM in the US.(12, 13, 34–38, 48, 51, 54, 55, 91) Among Black MSM across 6 US cities, an estimated 60% have reported being incarcerated during their lifetime,(51) and 39% were in financial crisis.(34) In comparison, approximately half of respondents had JSI, reported poverty or were unemployed. Poverty has been shown to moderate the effect of psychosocial factors on HIV infection.(92) This is one of the first studies to demonstrate that poverty, JSI, and community violence mutually enhance psychosocial and structural factors to synergistically increase HIV risk among YBTM.

Prior syndemic studies have included sexual, childhood and intimate partner violence,(22, 25, 26) but community violence has been overlooked. This study adds to the extant literature by assessing community violence exposure and found that 51% of participants experienced community violence. Likewise, prior Chicago-based research found that 56% of Black male high school students experienced being mugged or robbed.(82) In this study, syndemic factors such as substance abuse and depression were less prevalent than community violence, poverty and JSI, which may explain why previous studies have failed to consistently observe a syndemic effect on HIV risk among YBMSM.(21, 26, 28) The SAVA syndemic described by Singer was adapted to include mental health among MSM,(22, 23) and studies of syndemic factors among women and transwomen have incorporated transactional sex and incarceration.(32, 33) Our findings suggest that it may be necessary to consider JSI, poverty and community violence to comprehensively address the syndemic effect on vulnerability to HIV infection among YBTM.

We presented new findings of social network characteristics moderating the syndemic effect of psychosocial and structural factors on HIV risk among YBTM. The social network characteristics that significantly moderated syndemic effect included the number and proportion of friends, proportion of family, proportion of network members with JSI, the number of older network members, and the number of romantic network members. Interestingly, the proportion of friends in respondents' networks had a significant positive moderation effect on the relationship between syndemic index and HIV infection. One possible explanation is that friends may promote social norms that encourage HIV-related transmission behaviors, such as CAS.(93, 94) This explanation would be consistent with the concept of homophily in social networks, where respondents may be more likely to exhibit similar behaviors as their social network.(95) The presence of an "enabler," defined as a close network member who does not disapprove of risky behaviors, in the social networks of YBMSM has been positively associated with HIV-related transmission behaviors.(71) Our findings support both explanations for why friends amplify the association between syndemic and HIV infection. Results documented that having at least one network member who was a friend strengthened the association between the syndemic index and GS, which is consistent with the concept of an "enabler." It is possible that the moderating impact of friends is secondary to engaging in sexual risk behaviors with friends. However, we found that having ≥ 1 romantic network member buffered the syndemic effect on GS, which makes this unlikely. In the present study, we did not ask whether network members engaged in group sex or condomless anal sex, or the extent to which members approved or disapproved of respondents engaging HIV-related transmission behaviors. Future research should further elucidate the role of friends in social networks of YBTM and how they may impact HIV risk.

In contrast, the syndemic effect on HIV infection was buffered when networks consisted of $\geq 50\%$ family members. This finding is consistent with previous research demonstrating that greater family proportion in the social networks of Black MSM is associated with a decreased likelihood of engaging in HIV-related transmission behaviors.(18) Family may provide emotional and instrumental support that may result in greater psychological well-being and less unmet needs,(96, 97) and buffer the syndemic effect on HIV risk. A growing body of research suggests that the family members of YBTM may enact specific behaviors,

such as HIV testing and disclosure of same-sex behavior, that are significantly associated with HIV risk.(98–100) Importantly, our definition of family was inclusive of family of choice, and not necessarily kin, which may be indicative of connections to the larger YBTM community. Prior analyses with YBMSM has shown that stronger affiliations with the Black community are associated with greater HIV protective behaviors while stronger affiliations with the gay community are correlated with higher rates of sexual behaviors and reporting being HIV positive.(101) Consistent with this trend, social network interventions engaging family members have been associated with better engagement in care among YBTM living with HIV.(20) In our sample, 59% of respondents reported having at least one family member in their social network. These findings support the need for family-based network approaches to HIV prevention among YBTM.

Results also documented that having older social network members buffered the syndemic effect on HIV infection. This finding highlights a distinction from sexual networks, where increasing age has been positively associated with HIV risk.(102–104) While some studies have suggested that Black MSM may be less likely to disclose homosexuality,(9) Latkin et al. found that Black MSM were more likely to disclose their HIV status and same-sex behavior to social network members who are older, or who provide emotional and financial support.(105) In turn, "outness" has been shown to buffer the effect of syndemic factors on HIV risk,(65) which may explain our findings. Most of our study population had at least one social network member who was older, which may represent an untapped resource. Future research should continue to examine disclosure of MSM behavior among YBTM, and the influences exerted by older social network members and family in YBTM's networks.

Approximately half of respondents had at least 1 social network member with a history of JSI, and we found that having at least 1 social network member with JSI buffered the syndemic effect on CAS. While incarceration has been associated with increased HIV risk, (8, 54, 55) there has been conflicting evidence about the association between incarceration and CAS.(34, 93) Underhill et al.'s review of HIV prevention interventions in incarceration settings found up to 11 programs that reduced sexual risk taking.(106) Thus, social network members with JSI may be more likely to participate in effective HIV prevention interventions compared to those without JSI. In addition, previous analyses of the uConnect cohort demonstrated significant homophily between respondent and social network JSI.(17, 19) Thus, social networks with JSI may be more homophilous and more likely to disseminate behavioral norms that promote safe sex practices, such as condom use, which may explain this finding.

This study introduced a novel measure of social network syndemic index, and the number of syndemic factors within social networks also buffered the relationship between the syndemic index and CAS. However, our social network syndemic index was limited to JSI and illicit substance use (ISU), and very few respondents reported social network ISU without social network JSI (data not shown). Thus, the moderation effect of social network syndemic was likely attributable to social network JSI. Future studies may build on our findings, and further investigate the influence of social network syndemic index on risk of HIV infection. Lastly, unlike O'Leary et al,(28) respondent education did not moderate syndemic effect on HIV risk among our study population. However, this analysis focused on a younger

population, which suggests that the buffering effect of education on syndemic factors may be more prominent among older BMSM.

This study should be considered in the context of its limitations. First, this was a cross-sectional study that does not allow for causal implications. However, the moderation analysis is hypothesis generating and suggests potential pathways of influence that should be evaluated in future longitudinal research. Respondents were limited to reporting up to 5 social network members, which may influence the accuracy of social network characteristics. However, 90% of respondents reported 4 or less social network members (data not shown), so limiting social networks to 5 members unlikely impacted our results. We did not evaluate participation in larger networks, such as house balls, which may influence behavioral norms and risk of HIV infection among YBTM[107] and may be elucidated by future research. Though commonly used in behavioral research, major analyses relied on self-report measures, which are subject to social desirability bias that may result in underreporting of factors such as JSI and substance use. As in all social network elicitation research, respondents may not have full knowledge about social network members' HIV status or risk behaviors. However, individual risk behaviors are likely influenced by perceptions of network members' behaviors regardless if those perceptions are accurate.[108–110] Analyses included combined YBTM given the fluidity of gender identity and sexual orientation at this younger age that was observed in the cohort (data not shown), as well as that most Black TGW having gay or bisexual identities and limited access to gender affirming medical treatment pre-puberty. Lastly, sensitivity analysis with unweighted models produced significantly different results. The current study utilized RDS in order to evaluate YBTM who are often underrepresented in HIV research, and RDS can lead to bias. [86] We applied Gile's sequential sampling estimator with a reliable estimate of YBMSM on the South Side of Chicago in order to control for RDS bias. We would caution comparison to studies that do not use RDS, as there may be differences in study populations. For example, our study population included 9% (N = 54) transgender women compared to 5–7% in studies of YBTM that did not use RDS.[54, 55] Thus, our population was likely representative of YBTM on the South Side of Chicago, but may not be generalizable to other populations or studies that do not use RDS. Future studies may improve on RDS methodology in order to accurately evaluate risk of HIV infection among YBTM.

Conclusion

Our findings from this population-based sample of YBTM indicate that psychosocial and structural factors have a syndemic effect on HIV risk, and this effect is moderated by several social network characteristics. More specifically, this study highlights the importance of including incarceration, poverty and community violence as syndemic factors that contribute to increased HIV risk among YBTM. Future syndemic research should include those psychosocial and structural factors most relevant to the population of interest, as this information can be used to develop effective HIV prevention programs. Our findings also suggest that social network characteristics likely contribute to significant variability of syndemic effects on HIV risk among YBTM. Given the disproportionately high burden of HIV among YBTM, future research should further clarify which social network characteristics contribute to resilience versus vulnerability among YBTM.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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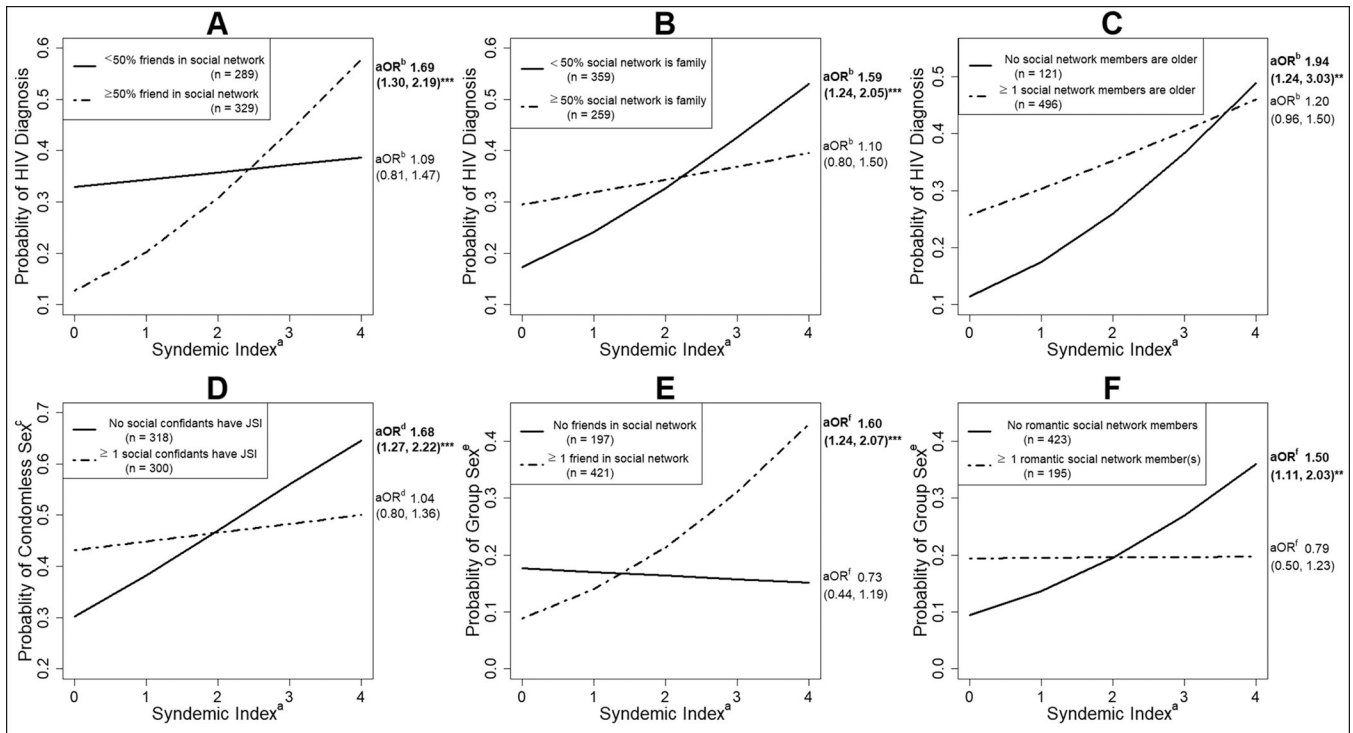
Figure 1: Predicted probabilities and adjusted odds ratios by syndemic index and stratified social network characteristics

** p ≤ 0.01; *** p ≤ 0.001

ISU = Illicit substance use (ecstasy, volatile nitrates, cocaine/crack, heroin, psychedelics or methamphetamines) in past 12 months.

JSI = Justice system involvement.

a. Presence of 1, 2, 3, ≥ 4 psychosocial and structural factors (ISU, depression, history of community violence, history of JSI, and poverty) among respondents.

b. Adjusted for respondent's age, sexual orientation, transgender identity, days spent in the justice system.

c. Condomless sex with male or transgender partner(s) in the last 6 months.

d. Adjusted for respondent's age, HIV dx, sexual orientation, education, employment status, days in the justice system, days since HIV diagnosis.

e. Group sex in the past 12 months.

f. Adjusted for respondent's age, HIV dx, transgender identity, days in the justice system, days since HIV dx.

Table I:

Description of study participant characteristics from the uConnect study cohort of young Black MSM and transgender women in Chicago, 2014 (n = 618)

	% (N)[a]
Median number of social network members (IQR)	2 (2, 3)
Median age (IQR)	23 (20, 25)
Sexual orientation	
Gay	66 (410)
Bisexual	27 (167)
Straight	4 (22)
Other	3 (19)
Transgender identity	9 (54)
Education[b]	
High school or less	39 (240)
some college	45 (280)
Undergraduate or graduate degree	16 (97)
Employment status	
Not employed	48 (295)
Part time (<30 hours/week)	28 (171)
Full time (≥30 hours/week)	25 (152)
Healthcare coverage	54 (332)
Illicit substance use in the past 12 months[c]	18 (110)
Depression[d, e]	12 (71)
History of community of violence[b]	51 (316)
History of justice system involvement[b]	46 (285)
Poverty[f]	53 (327)
HIV Diagnosis	34 (210)
Condomless Sex with male or transgender partner(s) in last 6 months	48 (299)
Group sex in the past 12 months[a]	21 (128)
Syndemic Index[d, g]	
0	16 (96)
1	27 (162)
2	27 (163)
3	20 (121)
≥ 4	9 (54)

IQR = interquartile range

[a.]Except where otherwise noted.

b.
Missing 1 due to incomplete data.

c.
Ecstasy, volatile nitrates, cocaine/crack, heroin, psychedelics, methamphetamines.

d.
Missing 22 due to incomplete data.

e.
Brief Symptom Inventory depression subscale t score > 62.

f.
Not having enough money in the household for rent, food, or utilities in the last 6 months or being homeless in the last 12 months.

g.
Presence of 5 psychosocial and structural factors (illicit substance use, depression, history of community violence, poverty, history of justice system involvement).

Table II:

Description of social network characteristics among participants from the uConnect study cohort of young Black MSM and transgender women in Chicago, 2014

Social network characteristic	Median (IQR) proportion[a]	Median (IQR) count[a]
Age[b]	27.00 (22.75, 33.42)	24 (21, 31)
≥1 year older	0.60 (0.33, 1.00)	1.00 (1.00, 2.00)
Peer[c]	0.33 (0.00, 0.50)	1.00 (0.00, 1.00)
Male	0.50 (0.33, 1.00)	1.00 (1.00, 2.00)
HIV +	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)
Illicit substance use[d]	0.00 (0.00, 0.00)	0.00 (0.00, 0.00)
Justice system involvement	0.00 (0.00, 0.50)	0.00 (0.00, 1.00)
Romantic	0.00 (0.00, 0.33)	0.00 (0.00, 1.00)
Friend	0.50 (0.00, 0.75)	1.00 (0.00, 2.00)
Family	0.33 (0.00, 0.60)	1.00 (0.00, 1.75)
Social Network Syndemic Index[e] [% (N)]		
0	48 (295)	
1	43 (264)	
2	9 (59)	

IQR = interquartile range

[a.] Statistics are reported as per respondent (n = 618) except where otherwise noted.

[b.] Among all social network members (n = 1566).

[c.] Within 1 year of respondent's age.

[d.] Illicit substance use (ecstasy, volatile nitrates, cocaine/crack, heroin, psychedelics, methamphetamines) in last year.

[e.] Presence of 0, 1, or 2 psychosocial or structural factors (ISU; JSI) within respondents' social network.

Table III:

Bivariate association between psychosocial factors, structural factors, HIV infection, condomless sex [e] and group sex [f]

	ISU[a]	Depression[b]	Community violence[c]	JSI[c]	Poverty[d]	HIV infection	Condomless sex
Depression[b]	3.03 (1.51, 6.11)**						
Community violence[c]	1.84 (1.02, 3.32)*	1.48 (0.80, 2.75)					
JSI[c]	4.09 (2.27, 7.36)***	1.90 (1.01, 3.59)*	2.19 (1.45, 3.32)***				
Poverty[d]	1.30 (0.72, 2.34)	3.17 (1.58, 6.36)**	1.88 (1.24, 2.85)**	2.15 (1.42, 3.25)***			
HIV infection	2.10 (1.16, 3.79)*	1.55 (1.00, 2.42)**	0.86 (0.55, 1.35)	1.95 (1.25, 3.03)**	1.90 (1.01, 3.59)*		
Condomless sex[e]	2.00 (1.10, 3.61)**	1.19 (0.79, 1.79)	1.08 (0.72, 1.63)	1.58 (1.05, 2.38)*	1.35 (0.73, 2.52)	2.10 (1.35, 3.28)**	
Group sex[f]	3.96 (2.11, 7.46)***	1.17 (0.69, 1.98)	0.87 (0.5261, 1.48)	2.25 (1.33, 3.80)**	2.06 (1.05, 4.02)*	1.85 (1.08, 3.20)*	1.59 (0.94, 2.68)

*
$p \leq 0.05$;

**
$p \leq 0.01$;

***
$p \leq 0.001$

JSI = Justice system involvement

ISU = Illicit substance use.

Illicit substances include ecstasy, volatile nitrates, cocaine/crack, heroin, psychedelics and methamphetamines in past 12 months.

[b] Brief Symptom Inventory subscale t score > 62.

[c] Lifetime history.

[d] Not having enough money in the household for rent, food, or utilities in the last 6 months or being homeless in the last 12 months.

[e] With male and transgender partner(s) in last 6 months.

[f] In the past 12 months.

Table IV:

Adjusted odds ratio of HIV infection and HIV transmission-related behaviors by syndemic index score and moderation by social network characteristics

HIV infection

	Model 1[g]: Direct (no moderator)	Model 2[h]: Friend[a] as moderator	Model 3[h]: Age[b] as moderator	Model 4[h]: Family[c] as moderator
Syndemic index	1.31 (1.08, 1.60)**	1.06 (0.80, 1.40)	1.99 (1.31, 3.01)**	1.63 (1.28, 2.06)***
Syndemic index [x] Friend(s)[a]		1.66 (1.13, 2.43)**		
Friend(s)[a]		0.26 (0.11, 0.59)**		
Syndemic index [x] Age[b]			0.60 (0.38, 0.96)*	
Age[b]			4.08 (1.52, 10.96)**	
Syndemic index [x] Family[c]				0.64 (0.43, 0.96)*
Family[c]				2.63 (1.11, 6.26)*

Group sex in the past 12 months

	Model 1a[i]: Direct (no moderator)	Model 2a[i]: Friend[d] as moderator	Model 3a[i]: Friend[a] as moderator	Model 4a[i]: Romantic[e] as moderator
Syndemic index	1.28 (1.00, 1.63)*	0.85 (0.55, 1.32)	0.97 (0.66, 1.42)	1.41 (1.06, 1.89)*
Syndemic index [x] Friend(s)[d]		1.80 (1.11, 2.93)*		
Friend(s)[d]		0.50 (0.18, 1.40)		
Syndemic index [x] Friend(s)[a]			1.64 (1.04, 2.57)*	
Friend(s)[a]			0.65 (0.24, 1.76)	
Syndemic index [x] Romantic[e]				0.64 (0.41, 1.00)*
Romantic[e]				2.21 (0.83, 5.89)

Condomless sex with a male or transgender partner in the past 6 months

	Model 1b[k]: Direct (no moderator)	Model 2b[l]: JSI[f] as moderator

Syndemic index	1.31 (1.09, 1.57) ***	1.56 (1.21, 2.01) ***	
Syndemic index [x] JSI [f]		0.67 (0.47, 0.96) *	
JSI [f]			2.15 (1.00, 4.63) *

Goodness-of-fit for all models was assessed using Akaike Information Criterion.

*
p ≤ 0.05;

**
p ≤ 0.01;

***
p ≤ 0.001

JSI = Justice System Involvement.

ISU = illicit substance use (ecstasy, volatile nitrates, cocaine/crack, heroin, psychedelics, methamphetamines) in past 12 months.

Syndemic Index = presence of 0, 1, 2, 3, ≥ 4 psychosocial and structural factors (ISU, depression, history of community of violence, history of JSI, and poverty) among respondents.

[a.] ≥ 50% of social network is friends.

[b.] ≥ 1 social network member who is ≥ 1 year older.

[c.] ≥50% of social network is family (blood or play).

[d.] ≥ 1 friend in social network.

[e.] ≥ 1 romantic members in social network.

[f.] ≥ 1 member with JSI in social network.

[g.] Adjusted for respondent's age, sexual orientation, transgender identity.

[h.] Adjusted for respondent's age, sexual orientation, transgender identity, days spent in the justice system.

[i.] Adjusted for respondent's age, HIV diagnosis (HIV dx), transgender identity.

[j.] Adjusted for respondent's age, HIV dx, transgender identity, days in the justice system, days since HIV dx.

[k.] Adjusted for respondent's age, HIV dx, sexual orientation, education, employment status.

[l.] Adjusted for respondent's age, HIV dx, sexual orientation, education, employment status, days in the justice system, days since HIV dx.