ABSTRACT

Title of dissertation: THE SYNDEMIC EFFECT OF PSYCHOSOCIAL AND STRUCTURAL FACTORS ON HIV TESTING AMONG BLACK MEN AND THE MODERATING EFFECT OF SEXUAL IDENTITY

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Black populations experience the highest incidence and prevalence of HIV in the United States. It has been posited that numerous structural and psychosocial factors contribute to HIV disparities among Black populations, these factors can have an adverse effect on healthcare utilization, including HIV testing. Given the burden of HIV rates among Black men, especially Black gay and bisexual men, it is important to consider possible barriers to HIV testing in this population. Syndemic theory posits a mutually reinforcement of social and structural conditions that cumulatively affects disease outcomes. While syndemic theory has been applied to HIV acquisition, this framework has not been utilized for HIV testing. We tested for a syndemic of depression, poverty, and a lack of healthcare access impacting HIV testing and tested sexual identity as a moderator of healthcare access in a nationally representative sample of Black men.

Participants with 2 or 3 syndemic factors were significantly more likely to have never been HIV tested compared to those with 0 or 1 (49.2% to 31.7%). Having 3 syndemic factors was associated with greater prevalence of never having been HIV tested (aPR=1.46, 95% CI 1.09, 1.95). Gay/bisexual identity moderated the association between health insurance and ever having been HIV tested in adjusted models (aPR=4.36; 95% CI 1.40, 13.62), with not having health insurance being associated with HIV testing among gay/bisexual participants only (aPR=4.84, 95% CI 1.19, 19.70). Using latent class analysis, four syndemic classes were

identified as significant predictors of having never been HIV tested. In adjusted log-binomial models, compared to the class with the lowest proportion of syndemic factors, the highest prevalence of never having been HIV tested was among the class with the highest proportions of syndemic component factors (aPR=2.27, 95% CI 1.83, 2.82). Overall, there is evidence of a syndemic of depression, poverty, and a lack of healthcare access that negatively affects HIV testing among Black men, with a lack of healthcare access being a significantly greater barrier to HIV testing among gay/bisexual men compared to heterosexual men.

THE SYNDEMIC EFFECT OF PSYCHOSOCIAL AND STRUCTURAL FACTORS ON HIV TESTING AMONG BLACK MEN AND THE MODERATING EFFECT OF SEXUAL IDENTITY

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Chapter 1 - Introduction

Background and Rationale

Sexually transmitted infections (STIs) are the most common notifiable infectious disease in the United States[1]. Reportable sexually transmitted infections, including gonorrhea, chlamydia, syphilis, and human immunodeficiency virus (HIV), are patterned by race, with Blacks in the United States (US) being the most affected racial group across all of the aforementioned infections[1]. In the US, Black men who have sex with men (BMSM) are the most affected by sexually transmitted infections (STIs), including gonorrhea, chlamydia, syphilis, and HIV[1, 2]. HIV incidence in particular has been steadily increasing in this population, with BMSM ages 13-29 years having the largest estimated increase in HIV incidence between 2006 and 2010[2]. BMSM face several risk factors that intersect, putting them at heightened risk for STIs, including discrimination and multiple discrimination-related stressors[3-5]. Furthermore, many BMSM experience syndemics, groups of mutually reinforcing psychosocial factors associated with several adverse health outcomes, related to HIV[5-7]. There has been an increased emphasis on exploring psychosocial and structural explanations for disparate rates of HIV in this group[8]. For example, there are unique social and structural factors, such as poverty and discrimination that BMSM may face that help explain these disparities[8-12].

Testing is a core component of HIV prevention, as this allows for initiation of treatment[13]. The majority of HIV infections among high-risk groups, particularly MSM are primarily transmitted by individuals who are not aware of their HIV status. Additionally, initiating highly active antiretroviral therapy for HIV positive individuals has not only been shown to lead to more optimal health outcomes among the individuals on treatment, but also

substantially reduces the ability to transmit HIV to others[14, 15]. For this reason, the treatment as prevention (TaP) strategy is now a cornerstone of HIV prevention. More broadly, there is an increased focus on minimizing the time between initial HIV infection and diagnosis. CDC guidelines recommend yearly HIV testing for heterosexual men and testing every six months for all sexually active gay and bisexual men; it is estimated however that up to 20% of HIV positive individuals are unaware of their status[2, 16].

There are several potential barriers to HIV testing, including multiple psychological barriers, such as depression, anxiety, lack of perceived risk, and confidentiality concerns[17, 18]. Additionally, there are structural barriers to HIV testing (e.g. finding the time to test, overall inconvenience, returning for results and the cost and location of testing services)[17-19]. Strategies to deliver HIV testing services to high risk populations have increasingly emphasized reducing barriers to testing as a core component of both national and community-based public health interventions.

Evaluating HIV testing behavior as an outcome helps to identify characteristics of those who do not receive HIV testing. Those who do not utilize HIV testing represent an at-risk population that could not be reliably studied if our outcome were HIV positivity. Additionally, those who do not utilize HIV testing include positive individuals who are unaware of their status; undiagnosed HIV positive individuals have the highest transmission rates due to the absence of treatment and thus a failure to reach undetectable viral loads[14].

Because of the scope of the epidemic of HIV, a major focus of public health research is finding effective methods to reduce incidence of HIV in marginalized populations[20-23]. Public health strategies in reducing incidence of HIV employ the investigation of several different risk factors, which include various social determinants of health[8-11, 24, 25]. These social determinants

are also particularly relevant when examining HIV among high risk racial groups, as there is no biological explanation for racial disparities in rates of HIV infection. While the aforementioned barriers are not entirely unique to Black individuals or sexual minorities, these barriers may contribute to disparities in HIV testing. Additionally, within the Black male population, it is not entirely clear how barriers to HIV testing differ between gay/bisexual men and heterosexual men, and if this has a differential impact on HIV testing between these subgroups of men.

Objective of the Research

The following studies examine psychosocial and structural barriers to HIV testing using multiple methods, including examining the cumulative syndemic effects of these barriers on HIV testing behaviors. For study 1, the factors of interest are healthcare access, depression, and poverty. While these studies do not utilize behavioral factors such as substance use and sexual risk taking, which are commonly used in syndemic theory, no studies have been established these factors as independent barriers to HIV testing. Socioeconomic factors, healthcare access, and mental health are not only mutually reinforcing, but are also independently associated with HIV testing, making these factors more suitable for syndemic theory in studying HIV testing outcomes. Study 2 examines the association between healthcare access and HIV testing, and how sexual identity moderates this association. Grounded in minority stress theory, barriers to healthcare may affect HIV testing behaviors among Black gay and bisexual men differently than they would for Black heterosexual men[26]. Study 3 also examines healthcare access, depression, and poverty as part of a syndemic using latent class analysis.

Theoretical Framework

Syndemic theory posits that mutually reinforcing psychosocial factors have a cumulative impact on HIV/STI-related risk outcomes[6, 7, 27-29]. Healthcare access, poverty, and depression have been shown in previous studies to be mutually reinforcing; for instance, poverty is associated with mental health[30]. Based on this framework, it is hypothesized that there will be evidence of a syndemic of poverty, depression, and low healthcare access associated with a higher prevalence of never having been HIV tested among Black men. Specifically, it is hypothesized that poverty, depression, and low healthcare access will be correlated with one another, and it is hypothesized that a higher syndemic index will be associated with higher prevalence of never having been HIV tested. Additionally, it is hypothesized that latent classes with higher probabilities of poverty, depression, and low healthcare access will be associated with greater prevalence of never having been HIV tested.

The rationale for testing for effect modification by sexual identity is grounded in Minority Stress Theory[26]. Minority stress theory posits that health disparities among sexual minority populations, such as gay and bisexual populations, are primarily explained by multiple stressors created in a discriminatory and prejudiced culture. This leads to experiences of discrimination, expectations of rejection, and internalized homophobia. These stressors may impact healthcare experiences, causing healthcare experiences to differ among Black sexual minority men compared to Black heterosexual men since these stressors exist in a context of a homophobic culture. We hypothesize that sexual identity will modify the association between healthcare access measures and never having been HIV tested among Black men.

Innovation and Significance

This research is a novel and innovative approach to examining how psychosocial factors affect HIV testing among Blacks in the United States and may provide valuable insight into how sexual minorities and heterosexuals differ by these factors within the Black population. The use of latent class analysis can identify unique combinations of risk factors that would not be detectable using conventional cumulative indices. This may better serve syndemic research aims in understanding HIV-related outcomes among high-risk populations.

Chapter 2 – Methods

Study Design

Data Source

All three studies utilize a cross-sectional study design, sampling from the Behavioral Risk Factor Surveillance System (BRFSS), a nationally representative cross-sectional telephone survey of approximately 400,000 adult participants in the United States. Data from this survey are weighted and collected using a stratified and clustered design. The BRFSS has been used in several sociological and epidemiological studies. Compared to previous iterations, the 2014 and 2015 BRFSS collect both land-line and cell-phone data, allowing access to more varied populations than a solely land-line phone survey will. This survey has multiple measures, which cover both psychosocial, behavioral, and structural risk factors. There are several measures of mental health and healthcare access in particular, as well as HIV testing. For these reasons, this dataset is an ideal choice to study the exposure variables of interest. Study 1 and 3 utilize 2015 data only. Study 2 pools 2014 and 2015 data, as both of these years include all of the healthcare access and sexual identity measures needed.

Participants and Criteria for Selection

This study is limited to Black men, ages 18 to 54, who self-identify either as straight (heterosexual), gay, or bisexual. Women, men of other races, and participants who did not report sexual identity are excluded from this study. Among Black men in the total dataset, approximately 97% self-identified with one of the aforementioned sexual identities.

Outcome Variable

The outcome variable for all three studies is never having been HIV tested (0=”Previously tested,” 1=”Never tested”). There may be some challenges with recall of HIV testing for those who have not been HIV tested in several years. The benefit to this measure however is that it may be easier to recall accurately than a frequency based measure, and will not vary within subject over time in the same way a frequency based measure will. Multiple studies have utilized this measure of HIV testing[31-33].

Exposure Variables

The psychosocial and structural factors to be tested as part of a syndemic include ever having been diagnosed with depression (0=”Never diagnosed,” 1=”Ever diagnosed”), poverty status (0=”No,” 1=”Yes”), and a combined healthcare barriers scale (ranging from 0 to 4). Poverty status was calculated using reported household income, and number of adults and children in the household. United States poverty thresholds for 2015, based on number of adults and children in the household, will be used to assign poverty status. The combined healthcare barriers scale was calculated by summing four healthcare barrier measures. These measures were having no health insurance (0=”No,” 1=”Yes”), not being able to see a doctor due to cost (0=”No,”1=”Yes”), not having a personal doctor (0=”No,” 1=”Yes”), and length of time since last routine checkup (0=”Within past year,”1=”Not within past year”). These four measures demonstrated moderate internal consistency (Cronbach’s alpha=0.6). The combined healthcare barriers scale was dichotomized at its median (categories 0 to 1, 2 to 4) to allow for coding equivalence with the other syndemic component factors and minimize the allocation ratio of the variable for optimum statistical power. In the third study utilizing latent class analysis, each

healthcare access measure was utilized as an individual predictor in generating latent classes rather than a summed scale.

Potential Confounders and Effect Modifiers

Sexual identity, the effect modifier of interest in study 2, is coded as ”Heterosexual” and ”Gay/Bisexual”. Differences between gay and bisexual participants could not be assessed due to an insufficient sample size. Grounded in minority stress theory, we are examining differences between individuals victimized by a homophobic culture (gay and bisexual people) and those who are not (heterosexual people), so the combining of gay and bisexual people is not substantially problematic. There are limitations to the sexual identity measure however, as there are more sexual identities that are not encompassed in this coding. Also, some BMSM may self-identify as heterosexual, leading to misclassification. Other BMSM may not self-identify with any of these choices, and may more closely self-identify with an identity such as same-gender loving, though it should be noted that approximately 97% of participants in the original sample did self-identify either as heterosexual, gay, or bisexual. There is a substantial limitation in the misclassification of gay/bisexual men who may identify as heterosexual, possibly to avoid homophobic stigma.

Covariates analyzed across all studies included education (Less than high school, High school, Some college, College graduate), age group (18 to 24, 25 to 34, 35 to 44, and 45 to 54), marital status (married, not married), and survey year (2014, 2015). Due to small sample sizes in the smallest categories for education and age, in study 1 and 3 education had to be collapsed into 3 categories (High school or less, Some college, College graduate) to achieve convergence using log-binomial modeling. Similarly, in study 3 age also had to be collapsed into 3 categories (18 to

34, 35 to 44, 45 to 54) to achieve convergence using log-binomial modeling. Household income and survey mode were also considered as covariates in study 2, though this did not change the effect estimates of any of the healthcare access measures by more than 10%, so it was not included in the model as a confounder. Survey year did not change the effect estimates of the length of time since last routine checkup by 10% or more either; though it was appropriate to include since data was pooled across years in study 2.

Statistical Approaches

Power analysis

For Welch's independent samples t-test, a power analysis was used to determine the sample size needed to achieve reasonable power (0.80) using the proposed analytic methods and a range of effect sizes. Cohen's suggestions for a small and moderate effect size d (0.2, and 0.5 respectively) will be used to determine power. Sample allocation ratios (n_1/n_2) ranging from 1 to 9 will be considered. 1 represents identical allocation between groups, while 9 is an extreme where 90% of participants are in one group.

At the small effect size d=0.2 and an allocation ratio of 1, a sample size of 788 will be needed to achieve a power of 0.80. At an extreme allocation ratio of 9 however, for a small effect size d=0.2 a total sample size of 2185 is needed to achieve a power of 0.80. While we will achieve this sample size within the stratum of Black heterosexual men, we are unlikely to achieve this sample size within the stratum of Black gay and bisexual men, as the sample of gay and bisexual men are likely to be much smaller than that of Black heterosexual men.

At a moderate effect size d=0.5 and an allocation ratio of 1, a total sample size of 128 will be needed to achieve a power of 0.80. Even at an extreme allocation ratio of 9, for a

moderate effect size d=0.5 a total sample size of only 353 is needed to achieve a power of 0.80. It appears that a moderate effect size will most likely be needed to detect differences among those who have and have not been HIV tested within the stratum of Black gay and bisexual men.

For the chi-square test, a power analysis was used to determine the sample size needed to achieve reasonable power (0.80) using a range of effects sizes. w=0.1 was be used for a small effect size and w=0.3 for a moderate effect size to determine power.

For a small effect size w=0.1, a total sample size of 785 is needed to achieve a power of 0.80. For a moderate effect size w=0.3, a total sample size of 88 is needed to achieve a power of 0.80. Similar to the previous Welch's independent samples t-test power analysis, it appears that for the larger sample of Black heterosexual men, even small effect sizes will be reliably detectable with reasonable power. Among the sample of Black gay and bisexual men however, a moderate effect size will most likely be needed to achieve reasonable power. All power analyses were conducted using GPower 3.0.10. There was less than 3% nonresponse across every variable except income, which had 7% nonresponse. There was no association between income nonresponse and any of the variables used in the study however, so a complete-case analysis was used.

Analysis

For all studies, bivariate analyses were conducted using the Rao-Scott chi square test. This was used to test differences in proportions of each psychosocial factor between men who have never been HIV tested and men who have been HIV tested. The Rao-Scott modification of the Chi Square test was used because it allows for the analysis of stratified and clustered data.

For the first study, correlations between all of the psychosocial factors were assessed by generating a correlational matrix. Phi coefficients were generated between all of the aforementioned variables. Significance of correlations was assessed for all variables using t statistics generated from the correlation coefficients. A cumulative psychosocial index (ranging from 0 to 3) was measured and tested between those who have ever been HIV tested and those who have not using the Rao-Scott chi-square test.

Model Specifications

For the first study, log-binomial models were used to generate prevalence ratios comparing the outcome at each level of the syndemic component index. Both an unadjusted model and a model adjusted for age, education, and marital status were generated. Additionally, unadjusted and adjusted models were generated including depression, poverty, and healthcare barriers as individual terms in the models. This allows for comparing the effects of each of these factors independent of the others, in contrast to the combined syndemic index.

For the second study, multivariate log-binomial regression modeling was used to generate prevalence ratios controlling for covariates, utilizing an interaction term for sexual identity and each of the three measures of healthcare access.

For the third study, log-binomial models were used to generate prevalence ratios comparing each predicted latent class to the reference class. The reference class is the class with the lowest probabilities of syndemic component factors. Both an unadjusted model and a model adjusted for age, education, and marital status were generated.

Assessment of Model Assumptions

For all studies, variance inflation and outliers were assessed by measuring the variance inflation factors and leverages respectively; there was no evidence of variance inflation (VIF<10) and no overly influential data points for any of the models. Covariance was assessed by calculating the variance inflation factor of each term; there was no evidence of covariance in any of the models. Outliers were assessed by examining the leverages of each observation; there was no evidence of overly influential points. As there were no continuous terms used in any of the models, there was no linearity assumption.

For the third study, a latent class model with 4 classes was used to test the unidimensionality assumption of a cumulative syndemic index. The factors studied were the same factors as in study 1. The patterns in probabilities of each psychosocial factor across each of the latent classes will indicate if the factor combinations reflect a unidimensional syndemic. To test the fit of a 4 class model, additional models with 3 and 2 classes were generated. A Likelihood Ratio Test was used to test if the 4 class model was a significantly better fit compared to the 3 class model, and I the 3 class model was a significantly better fit than the 2 class model. Demographic covariates and ever having been HIV tested was compared across each of the four latent classes. Additionally, log-binomial regression models were used to generate prevalence ratios for each latent class and covariates. Latent classes were generated in R 3.4.0 using the LCCA package, as this package allows for the incorporation of stratified and clustered data used in complex designs[34]. All other analyses were conducted in SAS 9.4[35].

Overall Study Strengths and Limitations

A strength of the study is the large sample size and use of a nationally representative dataset. This helps to maximize the generalizability of the study. Additionally, examining differences between gay/bisexual men and heterosexual men in this study can provide additional information on how psychosocial factors affect HIV testing in ways that previous studies have not. This can help to fill some gaps in the literature on HIV research.

An inherent limitation in the cross-sectional study design is the inability to assess temporality. There is some limitation in the exclusion criteria of self-reporting sexual identity. Individuals who are gay or bisexual may be more likely to report as heterosexual or refuse the question altogether due to stigma and discrimination targeted towards sexual minorities. Gay and bisexual participants reporting as heterosexual are likely to bias measured correlations towards the null. For those who decline to answer the question, it is difficult to determine how this may bias results, as it cannot be reasonably ascertained how those participants differ across psychosocial factors from gay and bisexual men who participated in the study. While the BRFSS is a large dataset, the subsample of Black gay and bisexual men is likely to be very small; this can create some limitations in statistical analyses. As mentioned with some of the variables, social desirability bias is a limitation due to the sensitive subject matter. The mode of the study also presents some limitations, as telephone surveys may exclude populations such as the homeless. A strength however is the use of both cellphone and land-line phones, as the populations of cellphone and land-line users are substantially different across several socioeconomic variables, especially across age.

Chapter 3 – Psychosocial and Structural Factors Impacting HIV Testing among Black Men (Manuscript 1)

Abstract

Black populations in the United States are disproportionately affected by HIV. These disparities may be driven by psychosocial and structural barriers to HIV testing which prevent initiation of the HIV care continuum, leading to undiagnosed infection and thus prolonged HIV transmissibility. Using data from a sample of 1,829 Black men in the 2015 Behavioral Risk Factor Surveillance System (BRFSS) we tested for differences in psychosocial and structural factors between Black men who had ever been HIV tested and those who have not, including testing for a syndemic of low healthcare access, depression, and poverty. Poverty status was associated with never having been HIV tested (Φ=.17, p<.001), 2 or more healthcare barriers (Φ=.10), and having had a diagnosis of depression (Φ=.19, p<.001). Having been diagnosed with depression was also associated with having 2 or more healthcare barriers (Φ=.08, p<.001). Participants with a syndemic factor index of 2 or 3 were significantly more likely to have never been HIV tested compared to those with an index of 0 to 1 (49.2% compared to 31.7%), consistent with a syndemic. A syndemic index of 3 was significantly associated with greater prevalence of never having been HIV tested in both unadjusted log-binomial regression models (PR=2.06, 95% CI 1.20-3.54) and models adjusted for age, education, and marital status (aPR=1.46, 95% CI 1.09-1.95). This study utilizes a novel approach to understanding how Black men who have never been HIV tested may be affected by the accumulation of poverty, mental health, and healthcare access.

Introduction

HIV remains a global epidemic, with notable racial disparities affecting Black populations in the United States[16]. Because of this, it is critical to identify potential psychosocial barriers to HIV testing in this population in order to effectively combat the HIV epidemic. A substantial proportion of HIV positive individuals are unaware of their status, ranging as high as 20% by some CDC estimates[2, 16]. Given the disparately high HIV rates, it is important to consider and describe the possible barriers to HIV testing among Black populations. HIV testing is the first step in the initiation of HIV treatment, which not only reduces the communicability of HIV but also helps prevent progression to AIDS[14, 15]. For this reason, testing is an extremely important component to managing existing cases as well as preventing new ones. As such, barriers to testing need to be well understood, especially in high-risk populations.

Many social and structural factors contribute to health disparities within Black populations[4, 5, 10, 36-38]. In addition to social/structural risk factors faced by Black sexual minorities, many studies illustrate how HIV-related outcomes among Black heterosexual men are affected by social and structural contexts, as well[39-41]. Mental health outcomes have been shown to impact multiple HIV-related outcomes; depression is significantly associated with more frequent condomless sex, more substance use, and lower adherence to antiretroviral medications[29]. Poverty can affect HIV testing behaviors through multiple channels, including lack of healthcare access, as well as a lack of HIV testing information and resources in impoverished areas[42, 43]. A study conducted by Gwads et al. found that a lack of HIV testing access and poverty were both associated with lower odds of recent HIV testing among a sample of Black and Latino heterosexuals[43]. As HIV testing is primarily delivered through healthcare

providers, access to healthcare is an important factor that impacts HIV testing behaviors among Black populations[44].

Syndemic theory posits that mutually reinforcing psychosocial factors have a cumulative impact on HIV/STI-related risk outcomes[6, 7, 27-29]. Healthcare access, poverty, and depression have been shown in previous studies to be mutually reinforcing; for instance, poverty is associated with mental health[30]. The correlation among these variables may provide support for examining these factors as part of a syndemic. A common method used in syndemic research is to examine a cumulative index of these factors[7]. Understanding differences between the populations of those who have been tested for HIV and those who have not can inform public health policy in promoting HIV testing in this population.

The objective of the study is to test for differences in depression, poverty status, and healthcare barriers between Black men who have ever been HIV tested and those who have never been HIV tested. Differences in a cumulative index of these three factors between Black men who have ever been HIV tested and those who have never been HIV tested will also be tested. Each of these factors have been shown in the literature to be associated with each other as well as associated with HIV testing, though this has not been studied in a nationally representative sample of Black men. The application of syndemic theory to understanding HIV risk factors among high risk populations predominantly focus on risk of HIV acquisition as the primary outcomes of interest[7, 27]. This study can further contextualize differences in HIV testing within the population of Black men. This approach has not been utilized in studying HIV testing outcomes, and represents a notable gap in the literature.

Methods

Sample

This is a cross-sectional study design examining data from the 2015 Behavioral Risk Factor Surveillance System (BRFSS), a nationally representative cross-sectional telephone survey of approximately 400,000 adult participants in the United States. Data from this survey is weighted and collected using a complex stratified and clustered design. Compared to previous iterations, the 2015 BRFSS collected both land-line and cell-phone data, allowing it to reach more varied populations that a purely land-line phone survey will. As some of the modules containing variables of interest were optional for each site in the data collection process, only the interviews where modules including the variables of interest were used were included for this study. All states were represented in the optional modules. There was less than 3% nonresponse across every variable except income, which had 7% nonresponse. There was no association between income nonresponse and any of the variables used in the study however, so a complete-case analysis was used.

This study is limited to Black men, ages 18 to 54 years of age, who self-identify either as straight (heterosexual), gay, or bisexual. Women, men of other races, and participants who did not report sexual identity are excluded from this study.

Measures

The outcome variable is ever having been HIV tested (No, Yes). This measure may be easier to recall accurately than a frequency based measure, and will not vary within subject over

time in the same way a frequency based measure will. Multiple studies have utilized this measure of HIV testing[31-33].

The psychosocial and structural factors included depression (Never diagnosed, Ever diagnosed), poverty status (Not in poverty, In poverty), and a combined healthcare barriers scale (ranging from 0 to 4). Poverty status was calculated using reported household income, and number of adults and children in the household. United States poverty thresholds for 2015, based on number of adults and children in the household, was used to assign poverty status. The combined healthcare barriers scale was calculating by adding four healthcare barrier measures. These measures were not having health insurance (Has Insurance, Has no insurance), not being able to see a doctor due to cost (Has never occurred, Has occurred), not having a personal doctor (Has personal doctor, has no personal doctor), and length of time since last routine checkup (Within past year, Not within past year). These four measures demonstrated moderate internal consistency (Cronbach's alpha=0.60). The combined healthcare barriers scale was dichotomized at its median (categories 0 to 1, 2 to 4) to allow for coding equivalence with the other syndemic component factors. Covariates included age (categories 18 to 24, 25 to 34, 35 to 44, and 45 to 54), education level (categories high school or less, some college, and college graduate), and marital status (Not married, Married). Due to the small sample size among gay/bisexual participants, sexual identity could not be included as a covariate in the log-binomial regression modeling.

Data Analyses

A Rao-Scott chi-square test was used to test differences in proportions of each psychosocial/structural factor and demographics between men who have never been HIV tested

and men who have been HIV tested. The Rao-Scott modification of the Chi Square test was used because it allows for the incorporation of stratified and clustered designs. Correlations between all of the psychosocial factors were assessed by generating a correlational matrix. Phi coefficients were generated between all of the aforementioned variables. Significance of correlations was assessed for all variables using t statistics generated from the correlation coefficients. A cumulative psychosocial index (ranging from 0 to 3) was measured and tested between those who have ever been HIV tested and those who have not using the Rao-Scott chi-square test.

Log-binomial models were used to generate prevalence ratios comparing the outcome at each level of the syndemic component index. Both an unadjusted model and a model adjusted for age, education, and marital status were generated. Additionally, unadjusted and adjusted models were generated including depression, poverty, and healthcare barriers as individual terms in the models. This allows for comparing the effects of each of these factors independent of the others, in contrast to the combined syndemic index. Variance inflation and outliers were assessed by measuring the variance inflation factors and leverages respectively; there was no evidence of variance inflation (VIF<10) and no overly influential data points for any of the models.

All data was analyzed in SAS using survey commands, incorporating sample weights and using statements to account for the stratified and clustered study design. Two-sided tests of significance with an alpha threshold of 0.05 were used for all inferences.

Results

Data from 1,829 Black male participants were analyzed, with approximately a third of these participants having never been HIV tested. Approximately a third of the sample was in poverty, and half of the sample had an education of high school or less. 97% of the sample identified as heterosexual. There was less than 3% nonresponse to all variables other than poverty status, which had 7% nonresponse. Nonresponse for poverty status was not significantly associated with any of the other covariates however, so a complete-case analysis was used.

Table 1 shows the association between each psychosocial factor and demographic with ever having been HIV tested. Participants who were never HIV tested were significantly more likely to be aged 18 to 24 years (31.5% compared to 9.6), be unmarried (69.8% compared to 52.6%), have an education of high school or less (51.2% compared to 40.3%), have no health insurance (23.1% compared to 15.7%), and be in poverty (42.5% compared to 26.0%). Participants with a syndemic factor index of 2 or 3 were significantly more likely to have never been HIV tested compared to those with an index of 0 to 1 (49.2% compared to 31.7%). When comparing proportions of HIV testing at each level of syndemic component factors, there was a clear trend of increasing proportions of never having been HIV tested with an increasing syndemic factor index (Figure 1).

Table 2 shows the correlations between each syndemic component factor and ever having been HIV tested. Poverty status was associated with never having been HIV tested (Φ=.17, $p<.001$), 2 or more healthcare barriers (Φ=.10, $p<.001$), and having had a diagnosis of depression (Φ=.19, $p<.001$). Having been diagnosed with depression was also associated with having 2 or more healthcare barriers (Φ=.08, $p<.001$).

In models including each of the syndemic factors individually (Table 3), only poverty was significantly associated with never having been HIV tested, and only in the unadjusted model 1 (PR=1.59, 95% CI = 1.27, 1.98). None of the factors were significant in the model 2 adjusted for education, age, and marital status. Models 3 and 4 show log-binomial regression estimates using the cumulative syndemic index. In the unadjusted model 3 using the syndemic index, we observed significant associations with never having been HIV tested among participants with a syndemic index of 2 (PR=1.52, 95% CI 1.13 to 2.05) and 3 (PR=2.06, 95% CI 1.20 to 3.54) compared to an index of 0. In the model 4 adjusted for education, age, and marital status, these associations were attenuated, though an index of 3 was still significantly associated with a higher prevalence of never having been HIV tested (aPR=1.46, 95% CI 1.09 to 1.95).

Discussion

This study shows that poverty, depression, and a lack of healthcare access form a syndemic impacting HIV testing among Black men. While each of these factors individually impact HIV testing behaviors, individuals affected by several of these factors may be especially discouraged from HIV testing. This may have an adverse effect on HIV testing promotion targeting Black men. The results also illustrate important needs to be considered when serving this community; there were notably high proportions of poverty among Black men who have never been HIV tested. Poverty is a particularly relevant factor given that it displayed the largest correlations with the other syndemic component factors measures.

A syndemic approach is a valuable method for understanding how psychosocial and structural factors impact HIV testing among Black men. There were correlations observed between poverty, healthcare access and mental health. The correlations among the syndemic

factors and ever having been HIV tested were generally small, but significant. The psychosocial index demonstrated an especially large increase in proportions of never having been HIV testing with an increasing number of factors, with the proportion of never having been HIV tested approximately twice as high among those who had all 3 syndemic component factors compared to those with 0 or 1. This may suggest that these factors have an individually small effect on each other, but a more pronounced cumulative effect on HIV testing behaviors. Andersen's healthcare utilization posits that utilization of healthcare services is determined by predisposing, enabling, and reinforcing factors[45]. Depression may be a predisposing factor under this model, while poverty, and a lack of healthcare access may represent enabling factors that may discourage HIV testing. The application of syndemic theory to healthcare utilization outcomes may further inform how predisposing factors impact enabling factors.

An inherent limitation in the cross-sectional study design is the inability to assess temporality. The measure of poverty is more recent that the outcome of ever having been HIV tested, making temporality a concern. Because the sample is almost entirely heterosexual, results cannot be readily generalized to gay and bisexual identifying Black men. It should be noted however that within heterosexual men, Black men account for the largest number of new cases[2]. There is also some limitation in the exclusion criteria of self-reporting sexual identity. Individuals who are gay or bisexual may be more likely to report as heterosexual or refuse the question altogether due to stigma and discrimination targeted towards sexual minorities. Finally, while variables were selected based on an association with HIV testing as well as associations documented in the literature, there may be relevant predictors that were not included, such as additional measures of mental health and stress.

Conclusion

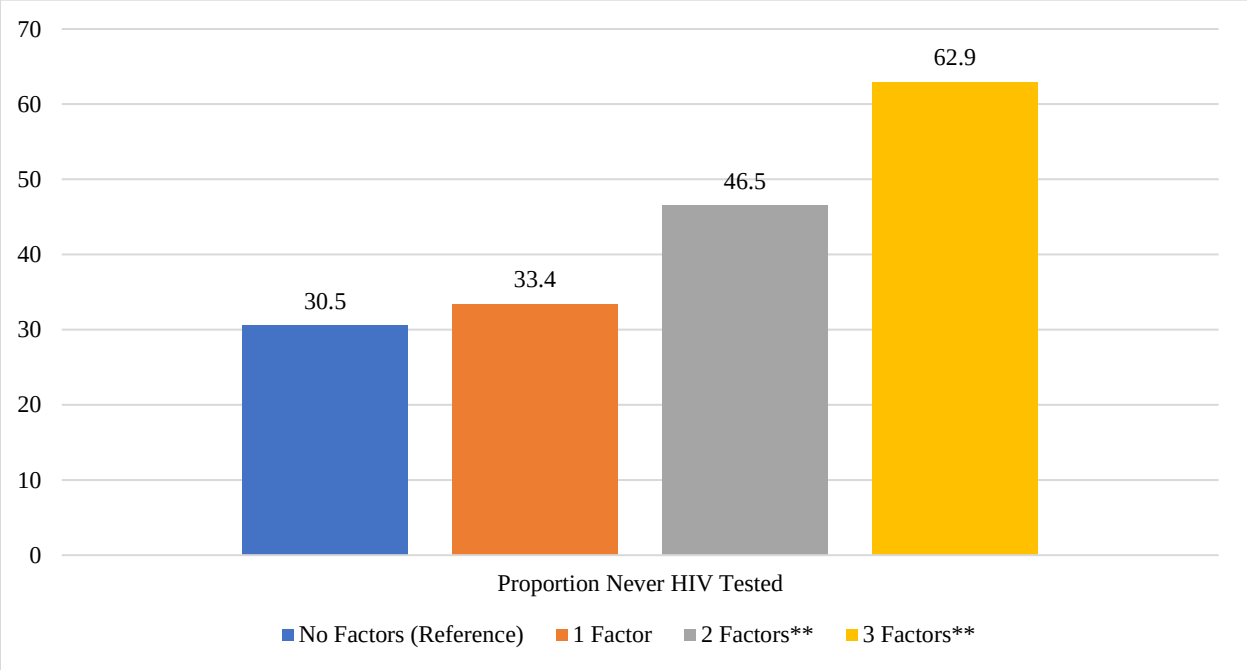
This research is a unique and informative approach to examining how psychosocial factors affect HIV testing among Black men in the United States. To our knowledge, this is the first study utilizing syndemic theory in studying HIV testing as an outcome. Understanding psychosocial barriers to HIV testing in a high-risk population can have a very tangible positive impact on public health strategies to reduce HIV incidence such as treatment-as-prevention; the TaP strategy of reducing HIV incidence is contingent on identifying HIV cases through testing so treatment can be initiated[14]. The ability to characterize high risk populations in terms of psychosocial risk factors can allow for more appropriately tailored and competent interventions. Further research into syndemics affecting HIV testing among BMSM may inform more specific interventions into HIV testing in this population as well.

Table 1. Demographic and psychosocial characteristics, stratified by HIV testing history (n=1,829)		
Variables	**HIV Tested (n=1216) %**	**Never HIV Tested (n=613) %**
Health Insurance*		
Has Insurance	84.3	76.9
Does not have Insurance	15.7	23.1
Personal Doctor		
Has personal doctor	73.4	69.7
Does not have personal doctor	26.6	30.3
Could not Access Doctor due to Cost		
Could access doctor	88.0	85.6
Could not access doctor	12.0	14.4
Time since last routine Checkup		
Less than 1 year	70.7	70.5
More than 1 year or never	29.3	29.5
Combined Healthcare Barriers Scale*		
0	51.6	48.7
1	25.4	23.7
2	13.6	12.8
3	6.6	12.0
4	2.7	2.8
Ever Diagnosed with Depression		
Not diagnosed with depression	89.4	88.1
Diagnosed with depression	10.6	11.8
Poverty Status***		
Not in poverty	74.0	57.5
In poverty	26.0	42.5
Highest Education Level***		
High school or less	40.3	51.2
Some college	33.4	33.6
College graduate	25.1	15.2
Sexual Identity		
Heterosexual	97.1	98.6
Gay / Bisexual	2.9	1.4
Marital Status***		
Not married	52.6	69.8
Married	47.5	30.2
Age Group***		
Age 18 to 24	9.6	31.5
Age 25 to 34	19.5	15.0
Age 35 to 44	35.6	18.8
Age 45 to 54	35.3	34.7
Syndemic Component Index**		
0	53.6	44.9
1	34.4	32.9
2	10.6	17.5
3	1.5	4.7
*p<.05, **p<.01, ***p<.001		

Table 2. Correlations between syndemic component factors and HIV testing (n=1,829)				
	Never HIV Tested	**Healthcare Barriers Scale ≥2**	**Ever diagnosed with Depression**	**Poverty Status**
Never HIV Tested	-	0.04	0.02	0.17***
Healthcare Barriers Scale ≥2	-	-	0.08**	0.14***
Ever diagnosed with Depression	-	-	-	0.19***
*p<.05, **p<.01, ***p<.001				

Table 3. Prevalence ratios and 95% confidence intervals for the association between the syndemic component factors and the syndemic index with ever having been HIV tested (n=1,829).				
	Model 1	**Model 2**	**Model 3**	**Model 4**
Ever Diagnosed with Depression				
Not diagnosed with depression	1.00	1.00		
Diagnosed with depression	0.97 (0.66, 1.41)	1.01 (0.72, 1.42)		
Poverty Status				
Not in poverty	1.00	1.00		
In poverty	**1.59 (1.27, 1.98)**	1.25 (0.99, 1.57)		
Combined Healthcare Barriers Scale				
Continuous	1.05 (0.94, 1.16)	1.04 (0.94, 1.15)		
Syndemic Component Index				
0			1.00	1.00
1			1.10 (0.85, 1.40)	0.90 (0.71, 1.13)
2			**1.52 (1.13, 2.05)**	1.19 (0.89, 1.60)
3			**2.06 (1.20, 3.54)**	**1.46 (1.09, 1.95)**
Education				
≤High school degree		1.00		1.00
Some college		0.93 (0.71, 1.20)		0.92 (0.72, 1.19)
College degree		0.86 (0.66, 1.13)		0.82 (0.62, 1.07)
Age				
18 to 24		1.00		1.00
25 to 34		**0.50 (0.34, 0.76)**		**0.49 (0.34, 0.72)**
35 to 44		**0.43 (0.30, 0.62)**		**0.40 (0.28, 0.57)**
45 to 54		**0.67 (0.51, 0.87)**		**0.61 (0.48, 0.78)**
Marital Status				
Unmarried		1.00		1.00
Married		0.84 (0.65, 1.09)		0.83 (0.64, 1.06)
*Estimates where p<.05 are bolded to facilitate interpretation. Estimates reflect the prevalence of never having been HIV tested in each group compared to the reference group.				

Figure 1: Proportion of never having been HIV tested across Syndemic Component Index (n=1,829)



*p<.05, **p<.01, ***p<.001

Chapter 4 – Sexual Identity Moderates the Association between Healthcare Access and HIV Testing among Black Men (Manuscript 2)

Abstract

Black men who have sex with men (BMSM) bear the highest HIV prevalence and incidence. Black heterosexual men also have higher HIV incidence than any other race within heterosexual men. Understanding differences in barriers to HIV testing between these two groups can help inform HIV promotion to these groups. This study aimed to test if sexual identity moderated the association between three healthcare access measures (not having health insurance, not having a personal doctor, and ever being unable to see a doctor due to cost) and ever having been HIV tested. A total of 2,091 participants in the 2014 and 2015 Behavioral Risk Factor Surveillance System were analyzed using multivariate log-binomial regression. Gay/bisexual identity significantly moderated the association between health insurance and ever having been HIV tested (PR=6.77; 95% CI 2.06 to 22.27). This effect was attenuated, but still significant after adjusting for education, age, marital status, and survey year (aPR=4.36; 95% CI 1.40 to 13.62). After adjusting for covariates, there was a significant association between not having health insurance and never having been HIV tested only among gay/bisexual participants (aPR=4.84, 95% CI 1.19 to 19.70). There was no significant moderating effect for not having a personal doctor and ever being unable to see a doctor due to cost. Future research is needed to understand why gay/bisexual men without insurance are more likely to never have an HIV test relative to heterosexual men without insurance.

Background

BMSM are the single highest risk group for HIV infection in the United States[1, 16]. BMSM face numerous psychosocial stressors that impact HIV testing behavior, including racial and homophobic discrimination[40, 46, 47]. Black heterosexual men, while not impacted by homophobia, still face racial HIV disparities[36, 37, 41, 48]. Both of these groups are disparately affected by psychological and structural factors associated with adverse health behaviors and outcomes.

While there is substantially larger HIV risk among Black sexual minority men compared to Black heterosexual men, both groups bear the largest burden of HIV prevalence and incidence within their respective stratum of sexual identity among men[1, 16]. There is a continued need for HIV testing promotion to both of these populations; effective promotion methods require understanding the differences in factors impacting HIV testing between these two populations. Several structural factors have been shown to impact HIV testing practices, so understanding how these factors affect HIV testing practices differently between Black heterosexual men and Black gay/bisexual men may better inform the development of interventions tailored to each of these populations. As HIV testing is the foundation of the treatment cascade, more in-depth understanding of how factors affect HIV testing in high-risk populations can contribute to greater success in combating the HIV epidemic.

Information on how sexual identity modifies the association between risk factors and health outcomes is relatively limited, but does generally support that sexual identity is a relevant modifier to consider; A study by Zellner et al. found that sexual identity modified the association between bisexual behavior and HIV risk, with the highest HIV risk observed among those who identified as heterosexual but engaged in bisexual sexual behavior[49]. A study by Grella et al.

found that sexual identity modified gender based disparities in unmet treatment needs for mental illness and substance use[50]. A study by Lahvot et al. on female veterans found that sexual behavior modified the association between age and alcohol misuse; there was a greater association between young age and alcohol misuse among women who had sex with women compared to women who only had sex with men[51]. Several studies illustrate the negative impact of social and structural factors on HIV/STI related outcomes among BMSM[3, 46, 47, 52, 53]. In a qualitative study by Malebranche et al., fear of racial discrimination and homophobia were both barriers to young Black gay men accessing healthcare services[54]. In addition to substantial evidence of psychosocial factors negatively impacting Black sexual minorities, there are also many studies showing how Black heterosexual men are also negatively impacted by psychosocial and structural factors [39-41]. A study by Gwadz et al found that both access to medical care and poverty were both predictors of HIV testing among heterosexual men (Gwadz, 2016).

The objective of the study is to test if sexual identity moderates the association between healthcare access and ever having been HIV tested. The study is grounded in Andersen's healthcare utilization model[45]. According to the model, healthcare utilization is determined by three types of factors: predisposing factors, enabling factors, and need. Healthcare access represents an enabling factor under this model. The rationale for testing for effect modification by sexual identity is grounded in Minority Stress Theory[26]. Minority stress theory posits that health disparities among sexual minority populations, such as gay and bisexual populations, are primarily explained by multiple stressors created in a discriminatory and prejudiced culture. This leads to experiences of discrimination, expectations of rejection, and internalized homophobia. These stressors may impact healthcare experiences, causing healthcare experiences to differ

among Black sexual minority men compared to Black heterosexual men since these stressors exist in a context of a homophobic culture. Testing for effect modification allows us to examine whether these stressors are different in sexual minorities (i.e., due to a homophobic culture). While there have been studies on how healthcare access affects HIV-related outcomes among racial minorities, studies generally have not tested effect modification of sexual identity before, which may be an important factor to consider [19, 52]. The majority of prior studies often do not provide nuanced information on whether associations differ across sexual minority status within Black men.

Methods

Sample

This study employs a cross-sectional design using data from the 2014 and 2015 Behavioral Risk Factor Surveillance System (BRFSS), a nationally representative cross-sectional telephone survey of approximately 400,000 adult participants in the United States. Data from this survey is weighted and collected using a complex stratified and clustered design. The 2015 BRFSS collected both land-line and cell-phone data, allowing it to reach more varied populations that a purely land-line phone survey will. Because some of the modules containing variables of interest were optional in the data collection process, only participant interviews where modules including the variables of interest were used were included for this study. All states were represented in the optional modules. Data was pooled across the two years. There was less than 3% nonresponse across every variable, so a complete-case analysis was used.

This study is limited to Black men, ages 18 to 54 years of age, who self-identify either as straight (heterosexual), gay, or bisexual. Women, men of other races, and participants who did not report sexual identity are excluded from this study.

Measures

Having never been HIV tested is the outcome variable of interest (Previously tested, Never tested). The benefit to this measure is that it may be easier to recall accurately than a frequency based measure, and will not vary within subject over time in the same way a frequency based measure will. Multiple studies have utilized this measure of HIV testing[31-33].

The primary exposure is healthcare access, operationalized as health insurance status (Insured, Uninsured), having a personal doctor (Has a personal doctor, No personal doctor), and ever having been unable to access a doctor due to cost (Never unable to access, Previously/currently unable to access). The moderator of interest is sexual identity (Heterosexual, Gay/Bisexual). There are limitations to the sexual identity measure however, as there are more sexual identities that are not encompassed in this coding. Some BMSM may not self-identify with any of these choices, and may more closely self-identify with an identity such as same-gender loving, though it should be noted that approximately 97% of participants in the sample did self-identify as either heterosexual, gay, or bisexual.

Covariates used included education (Less than high school, high school graduate, some college, College graduate), age group (18 to 24, 25 to 34, 35 to 44, and 45 to 54), marital status (married, unmarried) and survey year (2014, 2015). Education, age group, and marital status each produced a greater than 10% change in effect estimates for healthcare access measures, so these were included as confounders. While survey year did not change the effect estimates of any

of the measures of healthcare access by 10% or more, it is standard to adjust for survey year when pooling data, so this term was still included in all adjusted models.

Statistical Analysis

A Rao-Scott chi-square test was used to test differences in proportions of healthcare access and covariates between men who have never been HIV tested and men who have been HIV tested across strata of sexual identity. This modification of the Chi Square test was used because it allows for the analysis of stratified and clustered data. Multivariate log-binomial regression modeling was used to generate prevalence ratios (PR) comparing proportions of never having been HIV tested between those without each measure of healthcare access and those with healthcare access. Four models were generated; Model 1 only included the three healthcare access measures. Model 2 adds age, marital status, education, and survey year as covariates. Model 3 included the three measures of healthcare access, sexual identity, and an interaction term for sexual identity and each of the healthcare access measures. Model 4 adds age, marital status, education, and survey year as covariates to Model 3. Covariance was assessed by calculating the variance inflation factor of each term; there was no evidence of covariance in any of the models.

Results

A total of 2,201 Black, male participants aged 18 to 54 were analyzed (Weighted n=3,366,112). Approximately a third of participants had never been HIV tested. 97% of the sample identified as heterosexual. Approximately 80% of the overall sample had health insurance, and approximately 80% had never been unable to access a doctor due to cost.

Approximately 60% of the sample had a personal doctor. Nearly 90% of the sample had an education of high school or greater. Because there was less than 4% nonresponse to all variables used, a complete-case analysis was employed.

In bivariate analyses, among gay/bisexual participants who had never been HIV tested significantly more likely to not have health insurance (44.9% compared to 11.5%). Having a personal doctor and ever having been unable to access a doctor due to cost were not significantly associated with ever having been HIV tested. There was no significant association between any of the healthcare access measures and HIV testing among heterosexual participants. Among both heterosexual and gay/bisexual participants who had never been HIV tested were more likely to be age 18 to 24 compared to any other age group, particularly among gay/bisexual participants (86.2% compared to 10.9%). Education and marital status were not significantly associated with ever having been HIV tested.

There were no significant main effects of any of the healthcare access measures in any of the models. Gay/bisexual identity was significantly associated with lower prevalence of never having been HIV tested in both the unadjusted model 3 (PR=0.25; 95% CI 0.08 to 0.78) and the model 4 adjusted for covariates (aPR=0.23; 95% CI 0.08 to 0.72). Additionally, gay/bisexual identity significantly moderated the association between health insurance and ever having been HIV tested (PR=6.77; 95% CI 2.06 to 22.27). This effect was attenuated, but still significant after adjusting for education, age, marital status, and survey year (aPR=4.36; 95% CI 1.40 to 13.62). Based on Model 4, there is a significant association between not having health insurance and never having been HIV tested among gay/bisexual participants after adjusting for covariates (aPR=4.84, 95% CI 1.19 to 19.70). Among covariates in Model 4, compared to the reference age group of 18 to 24 years, age of 25 to 34 years (aPR=0.66; 95% CI 0.50, 0.86), 35 to 44 years

(aPR=0.62; 95% CI 0.47, 0.83), and 45 to 54 years (aPR=0.62; 95% CI 0.47, 0.83) were all associated with lower prevalence of never having been HIV tested. Marital status, education level, and survey year had no significant association with ever having been HIV tested in any of the models.

Discussion

A lack of health insurance was significantly associated with higher prevalence of never having been HIV tested, but only among gay/bisexual men. Gay and bisexual men may be more likely to utilize HIV testing channels that are funded fully or in part by health insurance. The absence of healthcare access may function as a barrier to HIV testing only for sexual minority men. This also has implications for how the treatment cascade may differ between heterosexual and gay/bisexual men, and may inform tailoring interventions to improve HIV testing promotion in these populations. Further research into how stages in the treatment cascade differ between heterosexual and gay/bisexual men may build upon these differences in the effects of healthcare access on HIV testing. Though gay/bisexual identity did not significantly moderate the association between a lack of healthcare access due to cost and HIV testing, this may be negatively impacted by information bias, as income-related measures can be prone to socially desirable reporting.

Though not statistically significant, within the sample a larger proportion gay and bisexual men who had never been HIV tested reported having a personal doctor compared to those who had been HIV tested. Gay and bisexual participants who had previously been HIV tested may be more likely to utilize channels of HIV testing outside of a personal doctor, such as testing through community centers, outreach organizations, and mobile clinics. As many of these

channels are targeted specifically towards the gay/bisexual/transgender (GBT) community, having a personal doctor may be more of a channel for HIV testing among heterosexual men compared to sexual minority men.

This study contributes to the literature on HIV testing among Black men in multiple ways. Firstly, this utilizes a nationally generalizable sample with a very large sample size. Sociodemographic proportions in this study were consistent with larger national statistics, further reinforcing this study's generalizability to Black male populations in the United States. The focus on sexual identity as an effect modifier of the association between healthcare access and HIV testing has not been explored in the literature. This allows for direct comparison of the association between healthcare access and HIV testing between heterosexuals and sexual minorities, and the results support examining the role of healthcare insurance as a mechanism to HIV testing differently based on sexual identity. The use of multiple dimensions of healthcare access also provides a nuanced understanding of healthcare access in these populations. This study provides support for future research examining the different components of healthcare access individually, as a single more generalized healthcare index or scale would not capture the significant differences observed in this study.

Because this study is limited to Black men, it is not generalizable to other racial groups, such as Latino populations also disparately affected by HIV. This restriction is appropriate given that Black men are disproportionately affected by HIV however, so there is value in examining this population. Additionally, this study does not examine how the participant's perception of risk of HIV impacts HIV testing behavior, as these measures were unavailable. Similarly, measures of healthcare providers' assessments of patient HIV risk are likely to impact the association between healthcare access and HIV risk. Because the outcome is never having been

HIV tested, there are limitations to the temporality of the measures of health insurance and having a personal doctor. The aim of this study is to identify key characteristics of the population of Black men who have never been HIV tested however, as this may help inform characteristics of those not effectively reached by current HIV testing promotion methods. There are limitations to the sexual identity measure, as this may be affected by nonresponse bias, though a study by Jans et al. found no significant trend in nonresponse to sexual orientation questions across a decade[55]. Additionally, differences in HIV risk differ based on sexual behavior rather than identity, although HIV risk differences are strongly reflected in sexual identity as well.

Conclusion

To our knowledge, this is the first study illustrating that health insurance status is a barrier to HIV testing for gay/bisexual Black men, but not heterosexual Black men. This study highlights differences in how a lack of healthcare access functions as a barrier to HIV testing between heterosexual and sexual minority Black men. Further study into the mechanisms of this moderating effect are recommended, such as how HIV testing is differentially promoted by healthcare providers to heterosexual and gay/bisexual patients.

Table 1. Demographic and healthcare access characteristics, stratified by sexual identity and HIV testing history (Unweighted n=2,091, Weighted n=3,295,989).

	Heterosexual Identity		**Gay/Bisexual Identity**	
	% among those previously HIV Tested (n=1,377)	**% among those Never HIV Tested (n=634)**	**% among those Previously HIV Tested (n=69)**	**% among those Never HIV Tested (n=11)**
Health Insurance				
Has insurance	81.4	79.0	**88.5**	**55.1**
Has no insurance	18.6	21.0	**11.5**	**44.9**
Ever Unable to Access Doctor Due to Cost				
Able to access	84.5	85.2	78.6	82.1
Unable to access	15.5	14.8	21.4	17.9
Personal Doctor				
Has personal doctor	63.0	61.4	79.2	92.2
No personal doctor	37.0	38.6	20.8	7.8
Education				
Less than high school	10.2	16.5	11.6	0.0
High school graduate	34.3	34.0	22.6	31.8
Some college	35.3	30.9	41.0	62.6
College graduate	20.1	18.6	24.7	5.6
Age				
18 to 24	**11.6**	**31.3**	**20.1**	**86.2**
25 to 34	**26.6**	**19.7**	**38.7**	**2.0**
35 to 44	**32.5**	**20.8**	**19.7**	**0.8**
45 to 54	**29.3**	**28.3**	**21.5**	**10.9**
Marital Status				
Unmarried	66.0	78.0	97.4	95.0
Married	34.0	27.0	2.6	5.0

All p-values calculated using a Rao-Scott chi-square test. Significant values ($p<.05$) bolded.

Table 2. Prevalence ratios of the association between healthcare access and ever having been HIV tested (Unweighted n=2,091, Weighted n=3,295,989).

	Model 1	**Model 2**	**Model 3**	**Model 4**
Health Insurance				
Has insurance	1.00	1.00	1.00	1.00
Has no insurance	1.15 (0.86, 1.55)	1.14 (0.88, 1.47)	1.12 (0.83, 1.51)	1.11 (0.85, 1.45)
Personal Doctor				
Has personal doctor	1.00	1.00	1.00	1.00
No personal doctor	0.94 (0.69, 1.30)	1.03 (0.79, 1.35)	0.96 (0.69, 1.32)	0.94 (0.75, 1.19)
Access Doctor Due to Cost				
Could access	1.00	1.00	1.00	1.00
Could not access	1.02 (0.81, 1.29)	0.96 (0.76, 1.21)	1.02 (0.81, 1.29)	1.04 (0.79, 1.37)
Sexual Identity				
Heterosexual			1.00	1.00
Gay/Bisexual			**0.25 (0.08, 0.78)**	**0.23 (0.08, 0.72)**
Gay/bisexual Identity * Health Insurance				
Has insurance			1.00	1.00
Has no insurance			**6.77 (2.06, 22.27)**	**4.36 (1.40, 13.62)**
Gay/bisexual Identity * Personal Doctor				
Has personal doctor			1.00	1.00
Has no personal doctor			**0.15 (0.03, 0.80)**	0.28 (0.06, 1.32)
Gay/bisexual Identity * Access Doctor Due to Cost				
Could access			1.00	1.00
Could not access			1.72 (0.68, 4.35)	1.65 (0.72, 3.79)
Education				
College graduate		1.00		1.00
Some college		0.85 (0.64, 1.14)		0.85 (0.63, 1.13)
High school graduate		0.95 (0.72, 1.24)		0.93 (0.71, 1.22)
Less than high school		1.32 (0.92, 1.88)		1.30 (0.91, 1.85)
Age				
18 to 24		1.00		1.00
25 to 34		**0.39 (0.28, 0.53)**		**0.40 (0.29, 0.54)**
35 to 44		**0.39 (0.27, 0.55)**		**0.39 (0.27, 0.55)**
45 to 54		**0.52 (0.41, 0.67)**		**0.52 (0.40, 0.67)**
Marital Status				
Unmarried		1.00		1.00
Married		1.05 (0.81, 1.35)		1.01 (0.78, 1.30)
Survey Year				
2014		1.00		1.00
2015		1.07 (0.51, 2.28)		1.10 (0.52, 2.35)

Bolded values indicate statistical significance ($p<.05$). Estimates reflect the ratio of prevalence of never having been HIV tested in each group compared to the reference group.

Chapter 5 – Latent Class Analysis of a Syndemic of Risk Factors on HIV Testing among Black Men (Manuscript 3)

Abstract

Syndemic methodology has been employed in several studies of HIV-related outcomes affecting Black men who have sex with men. In contrast to the most common method for assessing syndemics, the use of a syndemic component index, latent class analysis can identify unique combinations of risk factors that may form a syndemic. Analyzing a sample of 1,829 Black men from the 2015 Behavioral Risk Factor Surveillance System (BRFSS), we used a 4 latent class model based on depression, poverty, and healthcare access to predict ever having been HIV tested. Class 1 was characterized by low proportions of all of the risk factors, while Class 2 was characterized by high proportions of all the risk factors. Class 3 had relatively high depression (.2171) and poverty (.8903), but generally low barriers to healthcare access. Class 4 had some healthcare barriers, being the most likely to not have a personal doctor (.8267), and was the most likely to have no routine checkup in the past year (.6740), but had relatively low depression and poverty. Using log-binomial regression models, there was a significantly higher prevalence of never having been HIV tested among class 2 (PR=2.94, 95% CI 2.40, 3.59) and class 3 (PR=1.44, 95% CI 1.11, 1.87) compared to class 1. When adjusting for education, age, and marital status, the associations were attenuated but still significant for class 2 (aPR=2.27, 95% CI 1.83, 2.82) and marginally significant for class 3 (aPR=1.25, 95% CI 0.96, 1.63). Latent class analysis may better serve syndemic research aims in understanding HIV-related outcomes among high-risk populations. Future research using this method to evaluate HIV testing outcomes among BMSM is recommended.

Introduction

Black men and women in the United States bear the greatest burden of HIV incidence of any racial group[1]. Though Black men who have sex with men (BMSM) are most affected HIV, Black heterosexual men also have disparately high HIV incidence compared to heterosexual men of other races[2, 16]. A substantial proportion of HIV positive individuals are unaware of their status, ranging as high as 20% by some CDC estimates (CDC, 2011). There are many psychosocial and structural factors that affect HIV testing outcomes among Black men[4, 5, 10, 36-38]. Psychosocial barriers to HIV testing will ultimately impact HIV infection among Black men, as HIV testing is the first step in the treatment cascade, so understanding these barriers better informs health policy in addressing the HIV epidemic among the most at-risk communities[14]. Poverty, depression, and a lack of healthcare access have all been shown in previous research to function as barriers to HIV testing as well and are associated with other adverse HIV-related outcomes[29, 42, 44, 56, 57]. Additionally, there are correlations among these factors as well; poverty is associated with poor mental health, for example[30].

Studying poverty, depression, and a lack of healthcare access individually does not provide a complete picture of how they may affect HIV risk. There may be mutual reinforcement between these factors; for this reason, syndemic theory is a useful theoretical framework for identifying the cumulative impact of psychosocial and structural factors. Syndemic theory posits that multiple adverse health conditions have a synergistic, cumulative effect on adverse health outcomes, and has been used in several studies to examine the effects of multiple interacting psychosocial and structural risk factors on HIV-related outcomes[6, 7, 27-29]. A study by Dyer et al. on a cohort of men who have sex with men (MSM) found that increasing numbers of syndemic psychosocial conditions were associated with more condomless anal intercourse[7]. A study by

Mustanski et al. reported that a syndemic measure consisting of violence, substance use, and internalizing mental health factors was significantly positively associated with the number of condomless anal sex partners[6]. Increasing numbers of syndemic psychosocial factors have been shown to be associated with other HIV-related outcomes as well; a study by Kuhns et al. found that a higher number of psychosocial conditions was negatively associated with highly active antiretroviral therapy adherence in HIV-positive young adults[29]. Though the literature on syndemics affecting Black heterosexual men is very limited, there are multiple studies showing that social and structural factors can adversely affect HIV and STI related outcomes among Black heterosexual men[39-41]. HIV testing access and poverty were associated with lower odds of recent HIV testing in a sample of Black and Latino heterosexuals[43]. A study by Bowleg et. al additionally found associations between neighborhood context, depression, substance use, and sexual risk behavior in a sample of heterosexual Black men[39]. While the formation of psychosocial syndemics has been assessed in studying risk of HIV acquisition, this methodology has not been used in studying HIV testing outcomes. Additionally, there is a literature gap in studies of syndemics affecting Black heterosexual men[39].

Cumulative syndemic indices, which count the number of factors present, are the most common methodology employed in assessing syndemics[6, 7, 29]. Many studies have successfully demonstrated a syndemic of risk factors affecting HIV-related outcomes using a cumulative index of psychosocial factors. Cumulative indices assume however that each factor has an equivalent impact on the psychosocial factors of interest, and that the factors are each measures of a single unidimensional syndemic. Though cumulative psychosocial indices are often intuitive, due to these assumptions they may not completely capture the complexity of the interactions of various psychosocial and structural factors. Different combinations of syndemic

factors may have distinct effects on HIV risk that are not detectable when only incorporating the number of factors present. The objective of the study is to identify latent classes of HIV testing probabilities based on combinations of social and structural factors. This also allows us to determine if the latent classes of HIV testing deviate significantly from unidimensionality assumptions. A deviation from this assumption may provide support for the use of latent class analysis as opposed to a cumulative psychosocial index in future research into HIV-related syndemics. The primary syndemic factors of interest are healthcare access, depression, and poverty.

Methods

Sample

We employed a cross-sectional design using data from the 2015 Behavioral Risk Factor Surveillance System (BRFSS), a nationally representative cross-sectional telephone survey of approximately 400,000 adult participants in the United States. Data from this survey is weighted and collected using a complex stratified and clustered design. The 2015 BRFSS collected both land-line and cell-phone data, allowing it to reach more varied populations that a purely land-line phone survey will. Because some of the modules containing variables of interest were optional in the data collection process, only the interviews where modules including the variables of interest were used were including for this study. All states were represented in the optional modules. There was less than 3% nonresponse across every variable except poverty, which had 7% nonresponse. There was no association between poverty nonresponse and any of the variables used in the study however, so a complete-case analysis was used.

This study is limited to Black men, ages 18 to 54 years of age, who self-identify either as straight (heterosexual), gay, or bisexual. Women, men of other races, and participants who did not report sexual identity are excluded from this study.

Measures

The outcome variable is having never been HIV tested (Previously tested, Never tested). The benefit to this measure is that it may be easier to recall accurately than a frequency based measure, and will not vary within subject over time to the same degree that a frequency based measure will. Multiple studies have utilized this measure of HIV testing[31-33].

The psychosocial/structural factors include depression (Never diagnosed, Ever diagnosed), poverty status (Not in poverty, In poverty), health insurance (Has Insurance, Has no insurance), not being able to see a doctor due to cost (Has never occurred, Has occurred), not having a personal doctor (Has personal doctor, has no personal doctor), and length of time since last routine checkup (Within past year, Not within past year). The four healthcare access measures demonstrated moderate internal consistency (Cronbach's alpha=0.60). Poverty status was calculated using reported household income, and number of adults and children in the household. United States poverty thresholds for 2015, based on number of adults and children in the household, was used to assign poverty status. Covariates included age (18 to 34, 35 to 44, and 45 to 54), education level (High school or less, Some college, College graduate), marital status (Married, Not married), and sexual identity (Heterosexual, Gay/Bisexual). The age category of 18 to 34 was collapsed from the 18 to 24 and 25 to 34 age groups, due to relatively small frequencies in the 18 to 34 age group preventing convergence in log-binomial regression

modeling. Due to the very small sample size among gay/bisexual participants, sexual identity could not be included in the latent class analysis or log-binomial regression modeling.

Statistical Analyses

A Rao-Scott chi-square test was used to test differences in proportions of each psychosocial/structural factor and demographics between men who have never been HIV tested and men who have been HIV tested. The Rao-Scott modification of the Chi Square test was used because it allows for the incorporation of stratified and clustered designs.

A latent class model with 4 classes was used to assess the unidimensionality assumption of a cumulative psychosocial index, using poverty, depression, and the healthcare access measures to model the latent classes. The patterns in probabilities of each psychosocial factor across each of the latent classes indicated if the factor combinations reflect a unidimensional syndemic. To test the fit of a 4 class model, additional models with 3 and 2 classes were generated. A likelihood ratio test was used to test if the 4 class model was a significantly better fit compared to the 3 class model, and if the 3 class model was a significantly better fit than the 2 class model (Table 2). Because the 4 class model was a significantly better fit than the 3 class model (χ^2=1148.86, p<.001), the 4 class model was used in all subsequent analyses. Latent class analysis was conducted in R 3.4.0 using the LCCA package, as this package allows for the incorporation of stratified and clustered data used in complex designs.

Demographic covariates and ever having been HIV tested was compared across each of the four latent classes. Additionally, log-binomial regression models were used to generate prevalence ratios (PR). Both an unadjusted model and a model adjusting for age, education, and

marital status were included. Bivariate analyses and log-binomial regression modeling was conducted in SAS 9.4.

Results

Data from 1,829 Black male participants were analyzed, with approximately a third of these participants having never been HIV tested. Approximately a third of the sample was in poverty, and half of the sample had an education of high school or less. 97% of the sample identified as heterosexual. Because there was less than 3% nonresponse to all variables used, a complete-case analysis was used here.

Table 1 shows bivariate association between each syndemic component factor and demographic with ever having been HIV tested. Participants who were never HIV tested were significantly more likely to be aged 18 to 34 years (46.5% compared to 29.1%), be unmarried (69.8% compared to 52.6%), have an education of high school or less (51.2% compared to 40.3%), have no health insurance (23.1% compared to 15.7%), and be in poverty (42.5% compared to 26.0%).

Table 3 shows the probabilities of syndemic component factors across the 4 latent class model. The 4 latent class model was a significantly better fit than a 3 class model based on the likelihood ratio test (χ^2=1148.86, p<.001). Class 1 was characterized by low proportions of all of the risk factors, with the lowest proportions of depression (.0589), poverty, (.0730), not having health insurance (.0406), not having a personal doctor (.0645), and not having been able to access a doctor due to cost (.0527). Class 2 was characterized by high proportions of all the risk factors, with the highest proportions of depression (.3834), poverty (.9735), not having health insurance (.9180), not having a personal doctor (.9180), and not having been able to access a

doctor due to cost (.9183). Class 3 had relatively high depression (.2171) and poverty (.8903), but generally low barriers to healthcare access including the lowest proportions of not having a routine checkup in the past year (.1466). Class 4 had some healthcare barriers, being the most likely to not have a personal doctor (.8267), and was the most likely to have no routine checkup in the past year (.6740), but had relatively low depression and poverty.

Table 4 shows the bivariate association between the latent classes and both demographics and ever having been HIV tested. Class 2 was the most likely to have never been HIV tested (88.8%), followed by class 3 (43.5%), class 1 (30.2%) and class 4 (22.7%). Class 2 was the most likely to be aged 18 to 34 (63.8%), unmarried (83.1%), and have an education level of high school or less (83.4%). Class 1 was the most likely to be aged 45 to 54 (44.0%) and have graduated college (31%). Class 3 and 4 had similar demographics, with overall higher age and educational attainment than class 2, but lower than class 3.

Table 5 shows the results of the log-binomial regression models. Class 1, which was the class with the lowest probability of syndemic factors, was used as the reference group. In the unadjusted model, there was a significantly higher prevalence of never having been HIV tested among class 2 (PR=2.94, 95% CI 2.40, 3.59) and class 3 (PR=1.44, 95% CI 1.11, 1.87) compared to class 1. When adjusting for education, age, and marital status, the associations were attenuated but still significant for class 2 (aPR=2.27, 95% CI 1.83, 2.82) and marginally significant for class 3 (aPR=1.25, 95% CI 0.96, 1.63). Additionally, after adjusting for covariates class 4 has a significantly lower prevalence of never having been HIV tested (aPR=0.68, 95% CI 0.48, 0.96) compared to class 1. There was a lower prevalence of never having been HIV tested among participants aged 35 to 44 (aPR=0.66, 95% CI 0.49, 0.90) compared to those aged 18 to

34, and among married participants (aPR=0.75, 95% CI 0.60, 0.95) compared to unmarried participants.

Discussion

There were clear differences in HIV testing across latent classes, with the largest prevalence of never having been HIV tested among class 2, which had high proportions of all the syndemic component factors. Notably, class 3 only had high proportions of poverty and depression but generally low healthcare access barriers, and yet was the class with the second highest prevalence of never having been HIV tested. This may suggest that poverty and depression in tandem are particularly impactful barriers to HIV testing, with this impact exacerbated by the additional presence of healthcare access barriers. While class 1 had the lowest proportions of syndemic components overall, class 4 actually had a lower prevalence of never having been HIV tested after adjusting for age, education, and marital status. The high education, older age, and high proportions of marriage in class 1 may directly influence the low proportions of syndemic risk factors and high proportions of HIV testing in this class.

The latent class analysis identified specific combinations of psychosocial factors that were inconsistent with a unidimensional syndemic. While class 2 was characterized by high proportions of every risk factor, the patterns of probabilities of these factors were not uniformly parallel to HIV testing across classes. This suggests that each factor does not contribute equally to the syndemic. For example, poverty was distinctly proportioned within the two classes most likely to have never been HIV tested, with proportions greater than 80% in those classes, but did not have the lowest proportions in the class the least likely to have never been HIV tested. The use of latent class analysis allows for detection of key characteristics of this syndemic that would

not be detected using a cumulative syndemic index. It should be noted however that while there are some clear departures from assumptions of a cumulative syndemic index, overall the patterns observed are broadly consistent with previous research indicating that depression, poverty, and a lack of healthcare access can be barriers to HIV testing. In the context of potential interventions to improve HIV testing among Black men, the latent class analysis can inform some key characteristics of populations that need the most outreach. The high proportions of poverty in particular indicate that this is a significant factor to consider.

The use of a nationally representative dataset incorporating a stratified and clustered design is a strength of this study, as it is generalizable to Black men nationally. An inherent limitation in the cross-sectional study design is the inability to assess temporality. This study also does not address confounding, and does not aim to evaluate the individual effects of each psychosocial factor independent of the others. Rather, the focus is identifying the combinations of the factors present among Black men, and how these combinations affect HIV testing. Results cannot be generalized to gay and bisexual identifying Black men because the sample is predominantly heterosexual. Due to the very small proportions of sexual minorities in the sample, differences in sexual identity could not be measured. There may be distinct syndemic profiles that impact HIV testing patterns among sexual minorities that were not detected in this sample. While BMSM bear the greatest burden in HIV incidence and prevalence, it should be noted that within heterosexual men, Black men account for the largest number of new cases, indicating a significant racial disparity as well[2].

In accordance with syndemic theory, psychosocial and structural factors were selected based on their association with HIV testing and their associations documented in the literature, though there may be significant predictors that were not included, including additional measures

of mental health. As mentioned with some of the variables, social desirability bias is a limitation due to the sensitive subject matter.

Conclusion

This research contributes to the understanding of the ways in which psychosocial and structural factors interact to impact HIV testing among Black men in the United States. Moreover, the use of latent class analyses helps to elucidate some of the unique combinations of risk factors that would not be detectable using conventional cumulative indices. Latent class analysis may better serve syndemic research aims in understanding HIV-related outcomes among high-risk populations. Future research using this method to evaluate HIV testing outcomes among BMSM is recommended, as this represents a major gap in the literature.

Table 1. Demographic and psychosocial characteristics, stratified by HIV testing history (n=1,829)		
Variables	**HIV Tested (n=1216) %**	**Never HIV Tested (n=613) %**
Health Insurance*		
Has Insurance	84.3	76.9
Does not have Insurance	15.7	23.1
Personal Doctor		
Has personal doctor	73.4	69.7
Does not have personal doctor	26.6	30.3
Could not Access Doctor due to Cost		
Could access doctor	88.0	85.6
Could not access doctor	12.0	14.4
Time since last routine Checkup		
Less than 1 year	70.7	70.5
More than 1 year or never	29.3	29.5
Ever Diagnosed with Depression		
Not diagnosed with depression	89.4	88.1
Diagnosed with depression	10.6	11.8
Poverty Status***		
Not in poverty	74.0	57.5
In poverty	26.0	42.5
Highest Education Level***		
High school or less	40.3	51.2
Some college	33.4	33.6
College graduate	25.1	15.2
Sexual Identity		
Heterosexual	97.1	98.6
Gay / Bisexual	2.9	1.4
Marital Status***		
Not married	52.6	69.8
Married	47.5	30.2
Age Group***		
Age 18 to 34	29.1	46.5
Age 35 to 44	35.6	18.8
Age 45 to 54	35.3	34.7
*p<.05, **p<.01, ***p<.001		

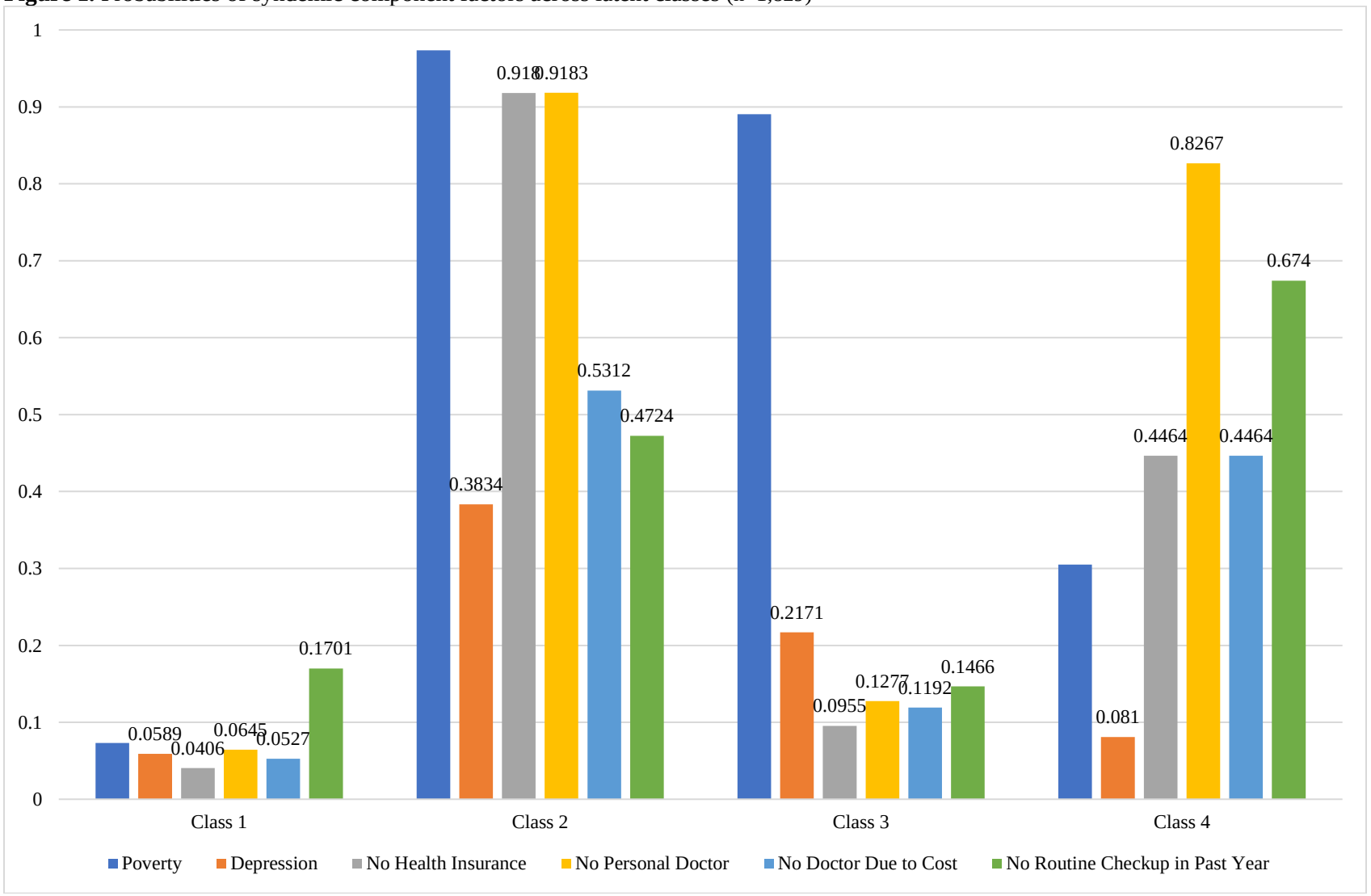
Table 2. Latent classes predicting ever having been HIV tested and log-likelihood (n=1,829)			
	4 Class	**3 Class**	**2 Class**
Log-Likelihood	-6254.50	-6828.93	-6863.74
Likelihood Ratio Chi-Square	1148.86***	69.62***	-
*p<.05, **p<.01, ***p<.001			

Table 3. Latent classes of HIV testing probabilities and associated factors (n=1,829)				
Predictors	**Class 1**	**Class 2**	**Class 3**	**Class 4**
Ever diagnosed with depression	.0589	.3834	.2171	.0810
Poverty status	.0730	**.9735**	**.8903**	.3050
Does not have health insurance	.0406	**.9180**	.0955	.4464
Does not have personal doctor	.0645	**.9183**	.1277	**.8267**
Could not access doctor due to cost	.0527	**.5312**	.1192	.4464
No routine checkup within past year	.1701	.4724	.1466	**.6740**
*Item-response probabilities for each predictor >.5 bolded to facilitate interpretation.				

Table 4. HIV testing and demographics across latent class membership (n=1,829)				
	Class 1 (n=1113) %	**Class 2 (n=58) %**	**Class 3 (n=315) %**	**Class 4 (n=343) %**
Highest Education Level* **				
High school or less	32.3	83.4	60.9	52.0
Some college	36.7	13.9	28.9	34.7
College graduate	31.0	2.7	10.2	13.3
Sexual Identity* **				
Heterosexual	96.9	100.0	98.7	98.0
Gay / Bisexual	3.1	0.0	1.3	2.0
Marital Status* **				
Not married	46.0	83.1	71.3	72.0
Married	54.0	16.8	28.7	28.0
Age Group* **				
Age 18 to 34	24.2	63.8	44.4	46.6
Age 35 to 44	31.8	16.6	25.9	31.8
Age 45 to 54	44.0	19.6	29.7	21.6
Ever HIV Tested* **				
Previously tested	69.8	11.2	56.5	77.3
Never tested	30.2	88.8	43.5	22.7
*p<.05, **p<.01, ***p<.001				

Table 5. Prevalence ratios and 95% confidence intervals for the association between latent class membership and ever having been HIV tested (n=1,829).		
	Model 1	**Model 2**
Latent Class Membership		
Class 1	1.00	1.00
Class 2	**2.94 (2.40, 3.59)**	**2.27 (1.83, 2.81)**
Class 3	**1.44 (1.11, 1.87)**	1.25 (0.96, 1.63)
Class 4	0.75 (0.53, 1.06)	**0.68 (0.48, 0.96)**
Education		
High school or less		1.00
Some college		1.02 (0.90, 1.15)
College degree		0.81 (0.63, 1.05)
Age		
18 to 34		1.00
35 to 44		**0.66 (0.49, 0.90)**
45 to 54		0.92 (0.79, 1.09)
Marital Status		
Unmarried		1.00
Married		**0.75 (0.60, 0.95)**
*Estimates where p<.05 are bolded to facilitate interpretation. Estimates reflect the ratio of prevalence of never having been HIV tested in each group compared to the reference group.		

Figure 1. Probabilities of syndemic component factors across latent classes (n=1,829)



Chapter 6 – Conclusions & Public Health Significance

Using a syndemic approach to understanding how psychosocial and structural factors affect HIV risk illustrates that there is a cumulative, mutually reinforcing effect between poverty, depression, and a lack of healthcare access on HIV testing among Black men. As public health strategies to combat the HIV epidemic increasingly focus on TaP and understanding gaps in the treatment cascade, it is important to thoroughly understand barriers to HIV testing in the populations most at risk for HIV infection. These populations include racial and sexual minorities, especially Black men who have sex with men.

In developing health policy for how to best combat the HIV epidemic in high risk populations, current understanding of psychosocial and structural risk factors may not be nuanced enough. Future HIV testing promotion programs should incorporate a multifaceted approach to needs assessment that identifies socioeconomic, mental health, and healthcare access barriers to HIV testing. Populations most impacted by these barriers may be ideal for target HIV testing interventions. As current policies hinge on the successful and timely testing of HIV positive individuals, barriers to HIV testing will translate to failures in HIV health promotion policies.

The use of latent class analysis identified classes of HIV testing behavior based on syndemic factors more strongly associated with never having been HIV tested than was observed using a cumulative syndemic index. Latent class may be ideal for gaining a more detailed understanding of HIV/STI related syndemics in future public health research. As effective public health strategies often rely on assessment of risk factors, this method is an invaluable tool in the assessment of syndemics.

References

1. 2014 Sexually Transmitted Diseases Surveillance. 2014.
2. HIV Surveillance Report. Centers for Disease Control and Prevention, 2011.
3. Ayala G, Bingham, T., Kim, J., Wheeler, D. P., & Millett, G. A. Modeling the impact of social discrimination and financial hardship on the sexual risk of HIV among Latino and Black men who have sex with men. *Am J Public Health* 2012;102(Suppl 2):S242-9.
4. Fields EL, Bogart, L. M., Galvan, F. H., Wagner, G. J., Klein, D. J., & Schuster, M. A. Association of discrimination-related trauma with sexual risk among HIV-positive African American men who have sex with men. *Am J Public Health* 2013;103(5):875-80.
5. Mustanski B, Garofalo, R., Herrick, A., & Donenberg, G. Psychosocial health problems increase risk for HIV among urban young men who have sex with men: preliminary evidence of a syndemic in need of attention. *Ann Behav Med* 2007;34(1):37-45.
6. Mustanski B, Phillips G, Ryan DT, et al. Prospective Effects of a Syndemic on HIV and STI Incidence and Risk Behaviors in a Cohort of Young Men Who Have Sex with Men. *AIDS Behav* 2016.
7. Dyer TP, Shoptaw, S., Guadamuz, T. E., Plankey, M., Kao, U., Ostrow, D., . . . Stall, R. Application of syndemic theory to black men who have sex with men in the Multicenter AIDS Cohort Study. *J Urban Health* 2012;89(4):697-708.
8. Magnus M, Kuo, I., Phillips, G., Shelley, K., Rawls, A., Montanez, L., . . . Greenberg, A. E. Elevated HIV prevalence despite lower rates of sexual risk behaviors among black men in the District of Columbia who have sex with men. *AIDS Patient Care STDS* 2010;24(10):615-22.

9. Clerkin EM, Newcomb, M. E., & Mustanski, B. Unpacking the racial disparity in HIV rates: the effect of race on risky sexual behavior among Black young men who have sex with men (YMSM). *J Behav Med* 2011;34(4):237-43.

10. Friedman SR, Cooper, H. L., & Osborne, A. H. Structural and social contexts of HIV risk among African Americans. *Am J Public Health* 2009;99(6):1002-8.

11. Millett GA, Flores, S. A., Peterson, J. L., & Bakeman, R. Explaining disparities in HIV infection among black and white men who have sex with men: a meta-analysis of HIV risk behaviors. 2007;21(15):2083-91.

12. Millett GA, Peterson JL, Flores SA, et al. Comparisons of disparities and risks of HIV infection in Black and other men who have sex with men in Canada, UK, and USA: a meta-analysis. *Lancet* 2012;380(9839):341-8.

13. Cohen M, Chen, YQ, McCauley, M, et al. Antiretroviral therapy for the prevention of HIV-1 transmission. *NEJM* 2016;375:830-9.

14. Antiretroviral treatment as prevention (TasP) of HIV and TB. Geneva: World Health Organisation, 2012.

15. Rodger A, Cambrioan, V, Bruun, T, et al. Sexual activity without condoms and risk of HIV transmission in serodifferent couples when the HIV-positive partner is using suppressive antiretroviral therapy. 2016(316):171-81.

16. Estimated HIV incidence in the United States, 2007–2010., 2012.

17. Callander D, Stoové M, Carr, A, Hoy, JF, Petoumenos, K, Hellard, M, Elliot, J, Templeton, DJ, Liaw, S, Wilson, DP, Grulich, A, Cooper, DA, Pedrana, A, Donovan, B, McMahon, J, Prestage, G, Holt, M, Fairley, CK, McKellar-Stewart, N. Barriers to HIV

testing and characteristics associated with never testing among gay and bisexual men attending sexual health clinics in Sydney. *BMC Infect Dis* 2016;16(1):752.

18. Marcus U, Gassowski, M, Drewes, J. HIV risk perception and testing behaviours among men having sex with men (MSM) reporting potential transmission risks in the previous 12 months from a large online sample of MSM living in Germany. *BMC Public Health* 2016;16(1):1111.

19. Frye V, Wilton L, Hirshfied S, et al. Just Because It's Out There, People Aren't Going to Use It." HIV Self-Testing Among Young, Black MSM, and Transgender Women. *AIDS Patient Care STDS* 2015;22(11):617-24.

20. Johnson WD, Diaz, R. M., Flanders, W. D., Goodman, M., Hill, A. N., Holtgrave, D., ... McClellan, W. M. Behavioral interventions to reduce risk for sexual transmission of HIV among men who have sex with men. *Cochrane Database Syst Rev* 2008;16(3).

21. Nyamathi A, Reback, C. J., Shoptaw, S., Salem, B. E., Zhang, S., & Yadav, K. Impact of Tailored Interventions to Reduce Drug Use and Sexual Risk Behaviors Among Homeless Gay and Bisexual Men. *Am J Mens Health* 2015:pii: 1557988315590837.

22. Rhodes SD, Alonzo, J., Mann, L., Freeman, A., Sun, C. J., Garcia, M., & Painter, T. M. Enhancement of a Locally Developed HIV Prevention Intervention for Hispanic/Latino MSM: A Partnership of Community-Based Organizations, a University, and the Centers for Disease Control and Prevention. *AIDS Educ Prev* 2015;27(4):312-32.

23. Manhart LE, Epstein, M., Bailey, J. A., Hill, K. G., Haggerty, K. P., & Catalano, R. F. HIV/Sexually Transmitted Infection Prevention Messaging: Targeting Root Causes of Sexual Risk Behavior. *Sex Transm Dis* 2016;43(2):71-7.

24. Millett GA, Peterson, J. L., Wolitski, R. J., & Stall, R. Greater risk for HIV infection of black men who have sex with men: a critical literature review. *Am J Public Health* 2006;96(6):1007-19.

25. Sifakis F, Hylton, J. B., Flynn, C., Solomon, L., Mackellar, D. A., Valleroy, L. A., & Celentano, D. D. Racial disparities in HIV incidence among young men who have sex with men: The Baltimore Young Men's Survey. *J Acquir Immune Defic Syndr* 2007;46(3):343-8.

26. Meyer IH. Prejudice, social stress, and mental health in lesbian, gay and bisexual populations: Conceptual issues and research evidence. *Psychol Bull* 2003;129:674-97.

27. Singer MC, Erickson P, L. B, et al. Syndemics, sex and the city: Understanding sexually transmitted diseases in social and cultural context. *Soc Sci Med* 2006;63(8):2010-21.

28. Martinez O, Arreola, S, Wu, E, Muñoz-Laboy, M, Levine EC, Rutledge, SE, Hausmann-Stabile, C, Icard, L, Rhodes, SD, Carballo-Diéguez, A, Rodríguez-Díaz, CE, Fernandez, MI, Sandfort, T. Syndemic factors associated with adult sexual HIV risk behaviors in a sample of Latino men who have sex with men in New York City. *Drug Alcohol Depend* 2016;166:258-62.

29. Kuhns LM, Hotton AL, Garofalo R, et al. An Index of Multiple Psychosocial, Syndemic Conditions Is Associated with Antiretroviral Medication Adherence Among HIV-Positive Youth. *AIDS Patient Care STDS* 2016;30(4):185-92.

30. Moskowitz D, Vittinghoff E, Schmidt L. Reconsidering the Effects of Poverty and Social Support on Health: A 5-Year Longitudinal Test of the Stress-Buffering Hypothesis. *J Urban Hlth* 2013;90(1):175-84.

31. Mechant RC, Freelove SM, Langan TJ, et al. The relationship of reported HIV risk and history of HIV testing among emergency department patients. *Postgrad Med* 2010;122(1):61-74.

32. Card KG, Lachowsky NJ, Cui Z, et al. Exploring the role of sex-seeking apps and websites in the social and sexual lives of gay, bisexual and other men who have sex with men: a cross-sectional study. *Sex Health* 2016:doi: 10.1071/SH16150.

33. Aholou TM, Nanin J, Drumhiller K, et al. Opportunities for HIV Prevention Communication During Sexual Encounters with Black Men Who Have Sex with Men. *AIDS Patient Care STDS* 2016:[Epub ahead of print].

34. Schafer JL, Kang J. *LCCA package for R users' guide (Version 1.1.0)*. University Park: The Methodology Center, Penn State; 2013.

35. *Base SAS® 9.3 Procedures Guide*. Cary, NC: SAS Institute Inc.; 2011.

36. Bowleg L, Fitz CC, Burkholder GJ, et al. Racial discrimination and posttraumatic stress symptoms as pathways to sexual HIV risk behaviors among urban Black heterosexual men. *AIDS Care* 2014;26(8):1050-7.

37. Brondolo E, Gallo, L. C., & Myers, H. F. Race, racism and health: disparities, mechanisms, and interventions. *J Behav Med* 2009;32(1):1–8.

38. Galvan FH, Davis, E. M., Banks, D., & Bing, E. G. HIV Stigma and Social Support among African Americans. *AIDS Patient Care STDS* 2008;22(5):423-36.

39. Bowleg L, Neilands T, Tabb LP, et al. Neighborhood Context and Black Heterosexual Men's Sexual HIV Risk Behaviors. *AIDS Behav* 2014;18(11):2207–18.

40. Bowleg L, Teti M, Malebranche DJ, et al. “It’s an uphill battle everyday": Intersectionality and the implications of social-structural factors for sexual HIV risk among Black heterosexual men. *Psychol Men Masc* 2013;14(1):25-34.

41. Cené CW, Akers, A. Y., Lloyd, S. W., Albritton, T., Powell Hammond, W., & Corbie-Smith, G. Understanding social capital and HIV risk in rural African American communities. *J Gen Intern Med* 2011;26(7):737-44.

42. Levy M, Wilton L, Phillips G, et al. Understanding Structural Barriers to Accessing HIV Testing and Prevention Services Among Black Men Who Have Sex with Men (BMSM) in the United States. *AIDS Behavior* 2014;18(5):972-96.

43. Gwadz M, Cleland CM, Kutnick A, et al. Factors Associated with Recent HIV Testing among Heterosexuals at High Risk for HIV Infection in New York City. *Front Public Health* 2016;4:76.

44. Underhill K, Morrow K, Colleran C, et al. Access to Healthcare, HIV/STI Testing, and Preferred Pre-Exposure Prophylaxis Providers among Men Who Have Sex with Men and Men Who Engage in Street-Based Sex Work in the US. *PLOS One* 2014.

45. Andersen R. Revisiting the behavioral model and access to medical care: does it matter? *J Health Soc Behav* 1995;36(1):1-10.

46. Arnold EA, Rebchook, G. M., & Kegeles, S. M. 'Triply cursed': racism, homophobia and HIV-related stigma are barriers to regular HIV testing, treatment adherence and disclosure among young Black gay men. *Cult Health Sex* 2014;16(6):710-22.

47. Frye V, Nandi V, Egan J, Cerda, M, et al. Sexual orientation and race-based discrimination and sexual HIV risk behavior among urban MSM. *AIDS Behav* 2015;19(2):257-69.

48. Kennedy SB, Nolen, S., Applewhite, J., Pan, Z., Shamblen, S., & Vanderhoff, K. J. A quantitative study on the condom-use behaviors of eighteen- to twenty-four-year-old urban African American males. *AIDS Patient Care STDS* 2007;21(5):306-20.

49. Zellner JA, Martínez-Donate AP, Sañudo F, et al. The Interaction of Sexual Identity With Sexual Behavior and Its Influence on HIV Risk Among Latino Men: Results of a Community Survey in Northern San Diego County, California. *Am J Pub Hlth* 2009;99(1):125-32.

50. Grella CE, Cochran SD, Greenwell L, et al. Effects of Sexual Orientation and Gender on Perceived Need for Treatment by Persons With and Without Mental Disorders. *Psychiatric Services* 2011;62(4):404-10.

51. Lehavot K, Williams EC, Millard SP, et al. Association of Alcohol Misuse With Sexual Identity and Sexual Behavior in Women Veterans. *Subst Use Misuse* 2016;51(2):216-29.

52. Brooks RA, Etzel MA, Hinojos E, et al. Preventing HIV among Latino and African American gay and bisexual men in a context of HIV-related stigma, discrimination, and homophobia: perspectives of providers. *AIDS Patient Care STDS* 2005;19(11):737-44.

53. Irvin R, Wilton, L., Scott, H., Beauchamp, G., Wang, L., Betancourt, J., Lubensky, M., Wallace, J., & Buchbinder, S. A study of perceived racial discrimination in Black men who have sex with men (MSM) and its association with healthcare utilization and HIV testing. *AIDS Behav* 2014;18(7):1272-8.

54. Malebranche DJ, Peterson, J. L., Fullilove, R. E., Stackhouse, R. W. Race and sexual identity: perceptions about medical culture and healthcare among Black men who have sex with men. *J Natl Med Assoc* 2004;96(1):97-107.

55. Jans M, Viana J, Grant D, et al. Trends in sexual orientation missing data over a decade of the California Health Interview Survey. *Am J Public Health* 2015:343-e50.

56. Onyeabor OS, Iriemenam N, Adekeye OA, et al. The effect of educational attainment on HIV testing among African Americans. *J Health Care Poor Underserved* 2013;24(3):1247-56.

57. Witzel TC, Melendez-Torres GJ, Hickson F, et al. HIV testing history and preferences for future tests among gay men, bisexual men and other MSM in England: results from a cross-sectional study. *BMJ Open* 2016;6(9):e011372.