INTIMATE PARTNER VIOLENCE, PSYCHOLOGICAL DISTRESS, AND HIV TESTING AMONG HETEROSEXUALLY ACTIVE INDIVIDUALS IN THE UNITED STATES

By

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Dissertation

Submitted to the Faculty of the

Graduate School of Vanderbilt University

in partial fulfillment of the requirements

for the degree of

DOCTOR OF PHILOSOPHY

in

Epidemiology

May 13, 2022

Nashville, Tennessee

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To my wonderful husband, John, for his constant love, support, and encouragement

and

our dog, Mando, for keeping me company and making me smile as I wrote most of this.

ACKNOWLEDGEMENTS

This work was supported by the National Institutes of Health (R01 MH113438, PI-Pettit) (K01 AI131895, PI-Rebeiro), the National Institute of Health funded Tennessee Center for AIDS Research (P30 AI110527), and the National Center for Advancing Translational Science (Clinical Translational Science Awards No. UL1TR000445 and TL1TR002244). This work was additionally supported by the Centers for Disease Control and Prevention National Behavioral Surveillance Grant (16-1601). Its contents are solely the responsibility of the authors and do not necessarily represent official views of the funding agencies.

I am beyond grateful to each member of my dissertation committee, Drs. Carolyn Audet, Meredith Brantley, Jessica Perkins, and Bryan Shepherd, whose combined expertise, guidance, and feedback were instrumental in the successful completion of this research. I would especially like to thank my primary mentor, Dr. April Pettit, for always offering incredibly valuable professional, educational, and occasionally emotional support throughout my PhD and MPH training. I am also appreciative of Dr. Peter Rebeiro, Jack Marr, and Samantha Mathieson, who were not members of my dissertation committee, but were always willing to provide meaningful feedback. I would also like to show my gratitude to the National HIV Behavioral Surveillance study group who provided the data and offered feedback on associated posters and presentations.

Lastly, I would like to thank all my family and friends for supporting me through this endeavor, especially my husband, John Schember, who always made sure I ate, slept, and relaxed an adequate amount throughout this entire process. I could not have gotten through this without him.

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I. BACKGROUND

HIV in the United States

In the United States (US), it is estimated that 1,189,700 persons were living with HIV (PLWH) and 36,801 people were newly diagnosed with HIV in 2019.[1] Approximately 65% of people newly diagnosed with HIV identified as men who have sex with men (MSM), and 23% were among heterosexuals.[1] Additionally, 80% of people newly diagnosed with HIV acquired HIV from someone who did not know they were living with HIV.[2] Of PLWH in the US, it is estimated that 87% know their HIV status.[1] The highest proportion of undiagnosed HIV among all those with HIV in the US is estimated to be among men with transmission attributed to heterosexual contact (16.6%), compared to MSM (15.2%).[1] Among heterosexual women living with HIV, 11.2% were undiagnosed.[1] MSM may get tested more than heterosexual men because they perceive themselves to be at greater risk for HIV acquisition, leading to a lower proportion of undiagnosed HIV in this group .[3,4] Women may have a lower rate of undiagnosed infections compared to men, as women tend to seek healthcare at higher rates than men, and opt-out HIV testing is strongly recommended for pregnant women by the Centers for Disease Control and Prevention (CDC).[5–7] Lack of knowledge of HIV status could lead to unknowingly transmitting HIV and not accessing antiretroviral therapy, which could subsequently lead to a poor quality of life, increased mortality, and increased community spread of HIV.[8]

Due to the importance of testing in combatting the HIV epidemic, the US identified strategies to improve HIV testing as a priority for their *Ending the HIV Epidemic (EHE): A Plan for America*.[9,10] The U.S. Department of Health and Human

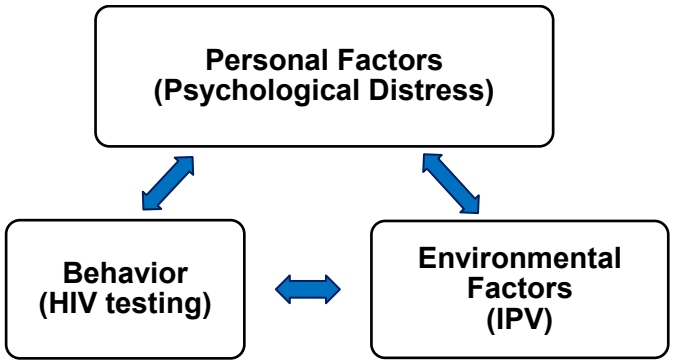
Services announced the *EHE* plan in February of 2019.[9,10] The goal was to reduce new HIV infections by 75% by 2025 and by 90% by 2030.[9,10] To achieve this goal, the *EHE* plan laid out four pillars which included testing and diagnosing HIV as early as possible after infection, treating rapidly and effectively to achieve viral suppression, preventing transmission, and responding quickly to HIV outbreaks.[9,10] Testing is the initial step to getting individuals linked to care, to prevent new transmissions, and to recognize potential outbreaks. Changing HIV testing behaviors among heterosexuals is, therefore, critical to help end the HIV epidemic in the US, as almost a quarter of individuals newly diagnosed are heterosexuals and HIV testing rates among this population are low.

Social Cognitive Theory to Understand HIV Testing Behaviors

Albert Bandura explained human behavior using Social Cognitive Theory, a three-part model where behavior, personal factors, and environmental influences interact with each another.[11] To change behaviors, one must understand how environmental and personal factors affect the behavior, and recognize the relationships between environmental and personal factors.[11] Social Cognitive Theory has previously been used to inform studies on HIV testing as seen in a qualitative study on stigma as a barrier to HIV testing and a study assessing factors associated with HIV testing among college aged MSM, and we believe Social Cognitive Theory could additionally inform our understanding of how intimate partner violence (IPV) and psychological distress may affect HIV testing.[12,13] We, therefore, ground this work in Social Cognitive Theory in order to assess our behavior of interest (HIV testing) in relation to environmental factors, including one's social setting and interactions, (experience of IPV) and personal

factors (psychological distress, **see Figure 1**).[14]. Other environmental and personal factors exist that impact HIV testing behaviors and may affect each other, are experience of stigma, socio-economic status, education, and marital status, to name a few. However, for this research we focused on the relationship between experience of IPV, psychological distress, and HIV testing. Understanding the relationship between environmental influences (IPV) and personal factors (psychological distress) is important to truly understand how these variables affect HIV testing, and how interventions on IPV and psychological distress may impact HIV testing.

Figure 1. Proposed Social Cognitive Theory Model



Assessing Intimate Partner Violence

IPV has been defined in many ways often depending on what is considered violence and who is considered an intimate partner. In the past, an intimate partner was only considered to be a spouse or cohabitating partner.[15] Today, most studies, consider an intimate partner as any sexual partner, which allows for a much more thorough assessment of violence.[16] Early studies focused primarily on physical violence and later began to additionally assess sexual violence.[15] Other studies have incorporated mental, emotional, and economic violence.[15] IPV can also be measured as victimization

(experiencing IPV) or perpetration of IPV.[15] IPV is commonly measured through survey questions that are specific to the study question and context.

All types of IPV have been shown to lead to increased risk of injury, chronic pain, gastrointestinal problems, and sexually transmitted infections in adult men and women, as well as mental health effects such as depression and post-traumatic stress disorder in women.[17] In the past IPV has been more commonly perpetrated by men against women, so most research has focused on the experience of women.[15] The CDC has estimated that 1 in 4 women, and 1 in 10 men experience some form of IPV each year.[18]

Data used in this study were collected before the coronavirus disease of 2019 (COVID-19), but with the ongoing pandemic, rates of IPV have increased as individuals are forced to quarantine with violent partners. International data have shown that IPV tripled in the Wuhan province of China during the beginning of the pandemic and has increased by 30% in France and 25% in Argentina.[19] Additionally, calls to a helpline for domestic violence increased by 30% in Cyprus and 33% in Singapore.[19] There already appears to be an increase in IPV in New York City and Portland, Oregon, areas hit early on in the pandemic where shelter at home orders were strict.[19] With COVID-19 continuing to spread in the United States, and more people needing to shelter at home, IPV is most likely increasing and services for individuals experiencing IPV may be more difficult to access. [19–21] We need to understand the downstream effects of this increased prevalence of IPV in order to prepare for other possible increases in public health issues caused by IPV.

Assessing Psychological Distress

Assessments of psychological distress, often defined as unpleasant feelings or emotions that impact an individual's level of functioning, can demonstrate a need for further testing for mental health disorders.[22] The need to test for and address psychological distress led to the creation of the Kessler Psychological Distress scale which has both a 10 question version and a shortened 6 question version, that gets at nervousness, hopelessness, restlessness, depression, worthlessness, and difficulty completing regular tasks in the past 30 days.[22] The 6 question version is used more frequently, because it has been shown to be as valid as the 10 question version, and requires the person being surveyed to answer fewer questions.[22] A validity study using the 2007 California Health Interview Study was conducted to determine a valid cut point for the Kessler scale, and found that a score 13 or higher, in a range of scores of 0-24, from the 6 question Kessler scale is a valid indicator for psychological distress.[23]

Psychological distress has also increased during the COVID-19 pandemic. A study on psychological distress among the general US adult population compared the years of 2018 and 2020.[24] This study found that 3.9% of US adults experienced psychological distress in 2018 and 13.6% of US adults experienced psychological distress in 2020, and predicted that this increase in psychological distress was likely due to the pandemic.[24] With psychological distress increasing, similar to IPV, we need to better understand how this may impact public health.

Previous Studies on the Relationship between Intimate Partner Violence and Psychological Distress

Multiple studies have shown a connection between IPV and psychological distress, but few have explored this association in both heterosexual men and women at high risk of HIV in the US. Three studies were of particular interest to this research due to the fact that they included primarily heterosexual United States populations.

The first study included 416 women on methadone in New York City surveyed at baseline and at a 12-month follow up to determine if childhood sexual abuse and IPV at baseline were associated with subsequent post-traumatic stress disorder and psychological distress.[25] They assessed IPV using the Revised Conflict Tactics Scale and psychological distress using the Brief Symptom Inventory with scores modeled as continuous variables.[25] Approximately 90% of the women in the study reported IPV at some point in their lifetime, and 78.2% reported IPV in the 6 months before the baseline interview.[25] Psychological distress at baseline was less common with a prevalence of 19.1%.[25] IPV in the past 6 months was associated with subsequent psychological distress with an adjusted odds ratio (aOR) of 2.67 (95% CI 1.12-6.34) compared to no experience of IPV.[25] The variables they adjusted for included childhood sexual abuse, age, race/ethnicity, education, marital status, years in methadone treatment, having more than one main partner, financial independence, post-traumatic stress disorder, HIV-positive status, alcohol use, drug use, and social support.[25] There are some limitations of this study emblematic of gaps in the literature. First, the measures for IPV and psychological distress utilized involved 39 questions about IPV and 49 questions about psychological distress making this survey less practical for regular clinical or

programmatic use. Additionally, they only assessed the relationship between IPV and psychological distress among women in opioid use disorder treatment at a single site, leaving out men who also experience IPV and women not in opioid use treatment, making this study less generalizable.

Another study conducted in 2019 evaluated IPV and psychological distress among 726 women 18-19 years of age residing in a single Michigan county.[26] They defined IPV as no violence, psychological violence only, or physical violence (with or without psychological violence).[26] They determined psychological violence by asking if their partner had sworn at, insulted, name-called, and/or disrespected them.[26] They determined physical violence by asking their partner had pushed, hit, or thrown something at them that could hurt.[26] Psychological distress was measured assessing depression, stress, loneliness, and self-esteem.[22,26] Prevalence of IPV in this population was 16.1% for psychological IPV and 3.2% for physical IPV any time before baseline.[26] IPV subsequent to psychological distress, as measured through weekly journals over 2.5 years, was experienced by 33.1% and 16.8% for psychological and physical IPV, respectively.[26] Among those with psychological distress at any time point, 25.9% experienced depression, 24.1% experienced stress, 26.6% experienced loneliness, and 48.5% experienced low self-esteem.[26] Psychological IPV was independently associated with an increased odds of depression (aOR=1.66, 95% CI: 1.01-2.74) and stress (aOR=2.29, 95% CI: 1.40-3.75) compared to no IPV; physical IPV was independently associated with increased odds of depression (aOR=3.33, 95% CI: 1.33-8.36), stress (aOR=3.12, 95% CI: 1.26–7.75), and loneliness (aOR=2.56, 95% CI: 1.02–6.40) compared to no IPV.[26] This study identified a connection between IPV and

psychological distress, but separately examined the types of IPV and disparate measures of psychological distress. However, this study did not include men and was conducted in a single Michigan county, limiting the generalizability.

A third study on IPV and psychological distress was conducted in 2007 using data from the CDC Behavioral Risk Factor Surveillance System (BRFSS) report. Among 5,985 men and 9,335 women included, 2.9% of the sample reported psychological distress (3.7% for women, 2.1% for men) and 15.5% of the sample reported some type of IPV (19.9% for women, 10.9% for men).[27] The IPV types assessed included threatened/attempted physical violence only, completed physical violence only, completed sexual violence only, and completed physical and sexual violence. Psychological distress was measured using the Kessler Psychological Distress Scale.[22] In analyses adjusting for age, gender, race, marital status, education, and employment status each type of IPV was independently associated with the presence serious psychological distress (aORs 3.9-7.8 depending on IPV type) compared to not experiencing that type of IPV.[27] When analyses were restricted to women, these associations remained (aORs 3.9-8.8 depending on IPV type). There were too few men experiencing IPV and psychological distress to perform meaningful analyses restricted to this group.

All three of these studies showed an association between IPV and psychological distress, but in different populations. In two of these studies, men were excluded, which is a major limitation in these studies as the relationship between IPV and psychological distress has been understudied in men.

Previous Studies on the Relationship between Psychological Distress and HIV Testing

One study among men in the US who are sexual minorities assessed the effect of psychological distress and perceived stigma on HIV prevention, including HIV testing.[28] This study used a survey meant to assess the impact of the changing social environment on the health and well-being of lesbian, gay, and bisexual individuals.[28] Conducted in 2017 and 2018, this study included 285 men who had sex with a man in the past year.[28] The Kessler 6 scale was used to measure psychological distress as a continuous measure. Participants were classified based on self-reported completion of testing for HIV at least once in the past year.[28] The proportion of participants who tested for HIV in the past year was 54.92%, and the mean Kessler Scale score was 6.68 (standard deviation: 4.45) indicating low psychological distress.[28] In their adjusted model, psychological distress was not significantly associated with HIV testing.[28] Limitations of this study were that they only assessed men who are sexual minorities and that they may have included individuals who are at low risk of HIV.

Another study using BRFSS data from 2007 specifically focused on the US South, included 21,156 participants (7,496 men and 13,660 women).[29] This study did not have any inclusion or exclusion criteria based on sexual practices as seen with the previous study.[29] Psychological distress was again measured using the Kessler 6 scale.[29] In this sample, serious psychologic distress was reported among 5.3% of men and 6.5% of women using the cutoff of >13 to determine psychological distress.[29] Self-reported HIV testing was more frequent among men with psychological distress (54.6%) compared to men without psychological distress (41.9%, p=0.003).[29] Similarly, self-

reported HIV testing was more frequent among women with psychological distress (55.1%) compared to women without psychological distress (45.5% p=0.0004).[29] The authors used survey weighting and did not perform a multivariable regression analysis controlling for confounders, which could explain the conflicting results between this study and the study described above. Regardless, these studies demonstrate the need to assess this relationship in a larger, more geographically diverse population, to better understand how psychological distress may affect HIV testing.

Previous Studies on the Relationship between Intimate Partner Violence and HIV Testing

Several studies have shown an association between IPV and a positive HIV test result [30–33]; however, few studies have addressed testing behaviors, regardless of the result. The studies that have addressed testing behaviors, were primarily conducted among women, and have conflicting results.

One study conducted in 2011 and 2012 included 3,504 women, and 11% had experienced either physical or sexual IPV in the past three months.[34] In this population, 11.2% of the overall population visited a clinic for STI testing or treatment.[34] Among adolescent and young adult women at one of 24 family planning clinics in Pennsylvania participating in this study, those who reported either physical or sexual IPV were more likely to have been tested or treated for any sexually transmitted infection (aOR=2.49, 95% CI: 1.87-3.31) compared to no experience of IPV. However, through combining testing and treatment, they were not able to make specific conclusions about testing alone, and they did not specifically assess HIV testing.

Another study conducted in 2015 including 100 women at two urban neighborhood sites of the Special Supplemental Nutrition Program for Women, Infants, and Children in the Mid-Atlantic Region, also demonstrated an association between IPV and HIV testing.[35] This study assessed IPV as psychological, sexual, and physical violence.[35] Among this population, 64% were tested for HIV in the past 6 months, 51% reported psychological IPV, 16.3% reported physical IPV, and 10.2% reported sexual violence.[35] Psychological IPV was the only type that was associated with a lower odds of HIV testing (aOR=0.02, 95% CI: 0.00-0.41) compared to no experience of IPV.[35] Although this study had a small sample size, experiencing IPV was still strongly associated with less HIV testing compared to not experiencing IPV.

An abstract presented at the 2019 National HIV Prevention Conference used the 2016 National HIV Behavioral Surveillance (NHBS) which surveyed 7,777 heterosexually active US men and women at increased risk of HIV. This abstract reported less frequent HIV testing among those experiencing IPV, but this study did not control for other covariates or stratify by gender.[36] This study included 7,777 men and women and 16.8% reported psychological and/or sexual IPV.[36] Among participants who reported IPV, 39.1% last received an HIV test more than a year before the interview, and 17.1% were never tested. Among participants who did not report IPV, 40.0% last received an HIV test more than a year before the interview, and 19.8% were never tested.[36] To our knowledge this is the only previous study to report on the relationship between IPV and HIV testing that included both men and women, but they did not stratify by gender or conduct multivariable regression analyses.

Two studies conducted using BRFSS data identified an association of IPV with increased rates of HIV testing.[37,38] One study, using 2006 and 2007 BRFSS data, including 30,182 women found a weighted prevalence of 22.6% for IPV at any point in their lifetime and 40.7% for ever being tested for HIV.[37] Those who experienced IPV at any point in their lifetime had a two times higher odds of previous HIV testing (aOR=2.34, 95% CI: 2.06-2.66).[37] The second study, using 2005 BRFSS data, including 29,209 women found that 28.6% experienced previous IPV, and 52.8% of women reported ever testing for HIV.[38] HIV testing was found to be independently associated with any IPV (aOR=1.52, 95% CI: 1.44-1.61).[38] This differs from the expected association that HIV testing would be less common among those who experienced IPV. Due to conflicting findings on the direction of the association between IPV with HIV testing, and the lack of men included in these studies, we assessed the relationship between IPV and HIV testing in a large, geographically diverse population of both men and women.

National HIV Behavioral Surveillance

National HIV Behavioral Surveillance (NHBS) is a CDC funded anonymous survey conducted by state and local health departments among populations at increased risk of HIV. NHBS systematically collects self-reported data on IPV, psychological distress, and HIV testing.[39] The purpose of NHBS is to estimate trends in, and demographic, social, and behavioral correlates of risk factors for HIV.[39] Another goal of NHBS is to measure trends in HIV/STI prevention services and characterize prevention-service gaps and missed opportunities for prevention.[39]

NHBS data are collected in three different yearly cycles focused on populations of MSM, people who use injection drugs, and heterosexual men and women at increased HIV risk. The 2016 and 2019 data for the heterosexual cycle, the two most recent, were used for this research.

NHBS anonymously surveys and provides testing for HIV and STIs in people at increased risk of HIV in 22 sites across the US.[39,40] These cities were chosen by CDC based on their high HIV burdens and high concentration of poverty, lower education, and racial minorities in urban areas.[39] Of those sites, the following 17 sites (77%) agreed to share their 2016 data for this project: Atlanta, Georgia; Boston, Massachusetts; Dallas, Texas; Denver, Colorado; Los Angeles, California; Memphis, Tennessee; Miami, Florida; Nassau-Suffolk, New York; New Orleans, Louisiana; Newark, New Jersey; Philadelphia, Pennsylvania; Portland, Oregon; San Diego, California; San Francisco, California; San Juan, Puerto Rico; Virginia Beach, Virginia; and Washington, DC.[39] The additional sites included in the 2019 sample were: Baltimore, Maryland; Chicago, Illinois; Detroit, Michigan; Houston, Texas; New York City, New York; and Seattle, Washington, and all these sites agreed to share their data. Of these sites, 18 (78%) are included as high priority areas in the US *EHE* Plan.[9,10]:Atlanta, Georgia; Boston, Massachusetts; Dallas, Texas; Los Angeles, California; Memphis, Tennessee; Miami, Florida; New Orleans, Louisiana; Newark, New Jersey; Philadelphia, Pennsylvania; San Diego, California; San Francisco, California; San Juan, Puerto Rico; Washington, DC; Baltimore, Maryland; Chicago, Illinois; Detroit, Michigan; Houston, Texas; New York City, New York; and Seattle, Washington.

Trained interviewers conduct the anonymous NHBS survey using a set script with guidelines to probe to get the most accurate information, even though these questions involve sensitive topics.[16] Interviewers enter answers from the survey into an electronic standardized data collection form. Data are then cleaned by the state Health Department where the interview was conducted prior to submission to the CDC.[39]

Detailed information on how interviews were conducted can be found in the interviewer guide.[16] In brief, interviews were conducted at a private area at a NHBS field site. Interviewers were hired for NHBS data collection by local project site staff from the associated Department of Health and trained using the interviewer guide in the conduct of face-to-face standardized interviews.[16,39] Standardized interviews increased internal validity through ensuring that the data were collected and measured the same way, regardless of the interviewer, the site where they were interviewed, and the date of the interview. To assist interviewers in asking questions in the same way and order, interviewers used Computer-Assisted Personal Interview (CAPI) software.[16,39] CAPI is a program which walks the interviewer through the interview and collection of the data.[16]

The interview began with obtaining informed oral consent. After obtaining consent, the interviewer started with a screener to determine eligibility for the study. The eligibility criteria for the heterosexual cycle were as follows: cisgender man or woman (nonbinary and transgender individuals were excluded), 18 - 59 years of age, current residence in one of the NHBS catchment areas, able to complete the survey in either English or Spanish (if the site had Spanish speaking interviewers), self-report of vaginal or anal sex with an opposite sex partner in the year before the interview, and self-report of being HIV-negative or unsure of their HIV status.[16] If an individual was deemed

eligible, the interview then began. These interviews included an approximately 40-minute survey that consisted of questions regarding participants' demographic characteristics, HIV testing history, sexual and drug-use behaviors, testing and diagnosis of sexually transmitted infections (STI), and use of HIV prevention services and programs.[16,39] In order to decrease the time-burden on participants, additional detailed questions were only asked if previous questions deemed this necessary using a technique called branching logic.[16,39]

In order to compensate participants for the time spent on the interview, for the heterosexual cycle, participants received between 20 and 30 US dollars, depending on the state where they were enrolled.[39] Condoms and anonymous HIV and STI testing were also offered to those who participated in the study.[39] Participants received an additional 10 to 25 dollars for HIV testing, and an additional 10 dollars for each person they recruited (up to 5) who completed the interview.[39]

Respondent-Driven Sampling

NHBS aims to recruit individuals at high risk of HIV, including sexual minorities, racial minorities, and people who inject drugs. Recruiting subjects for these studies can be difficult. NHBS uses Respondent-Driven Sampling (RDS) to recruit heterosexually active people and people who inject drugs.[39] RDS is a sampling method where participants recruit other participants in an effort to attain a larger sample of individuals who are typically difficult to recruit into studies.[41] In NHBS, an initial study population, known as the seeds, is identified through referrals from people who work in local clinics or other organizations designated by CDC as areas that would be high-yield for

recruitment of eligible individuals.[39] People who complete the NHBS survey are asked to recruit others through the use of coupons. Each respondent is given 5 coupons with a code on them, so when the coupons are redeemed, the additional recruits can be traced back to the respondent in order to pay the respondent for their recruits, and for the purpose of analysis. These codes allow researchers to identify recruitment chains which demonstrate how each participant is connected to their initial seed. Those conducting the NHBS survey accept coupons until the desired sample size of 500 participants per site is achieved or the 12-month sampling period ends.

RDS is a valuable method for recruiting participants from hard-to-reach groups. However. this method increases selection bias, depending on the seeds selected and who these seeds and other respondents recruit[42,43] due to a lack of independence between participants. One analysis that assessed RDS as a survey sampling method included 2,402 male household-heads in Uganda.[42] They had information on the full cohort of 2,402 male household-heads, but to assess RDS, sampled from this full cohort in real life using RDS to see if this sample was generalizable to the full population of 2,402 male household-heads.[42] They found that RDS produced a generally representative sample of male household-heads in Uganda as evidenced by similar prevalence rates in the sampled group and the full population of male household-heads, but advised caution when interpreting findings from this RDS due to possible bias caused by respondents recruiting other respondents very similar to themselves and potentially missing people from whom they differ.[42] Another analysis using NHBS injection drug use cycle data collected in Seattle, specifically addressed the RDS methods in an NHBS population.[43] This analysis found that the RDS led to certain age

groups and geographic areas of residence being overrepresented in the sample depending on who was recruiting other respondents.[43] Confounding caused by these factors (e.g. age and geographic area) could be controlled for through multivariable analysis, but the lack of independence between individuals needs to be controlled for using other methods.

Generalized Estimating Equations to Account for Lack of Independence between Participants Caused by Respondent Driven Sampling

One method employed to account for the lack of independence between participants using RDS includes generalized estimating equations (GEE). GEE is a method of determining parameters for a generalized linear model with unknown correlation of outcomes between or within individuals. GEE allows for the lack of independence between participants by incorporating a correlation structure clustering by recruitment chain. Assumptions of GEE include: 1) the outcomes are correlated or clustered between or within individuals, 2) there is a linear relationship between the covariates and the outcome, and 3) within-cluster covariance of the outcome has some structure.[44] These assumptions can be tested by assessing the within-cluster correlation, and GEE is actually fairly robust to misspecification of the correlation structure.[45] Some covariance structures include independence (observations within clusters are independent from each other), exchangeable (all observations have the same correlation to each other within a cluster), autoregressive (correlation decreases as observations get further apart in the cluster), and unstructured (correlation between all observations within a cluster may be different).[44,45]

Here we focus on two studies that are representative of different ways that GEE is used to account for bias caused by RDS. One 2020 multi-site NHBS publication used the same dataset that was used for this research and sought to assess the relationship between disability prevalence and HIV risk factors.[46] The authors used Poisson regression with GEE and robust standard errors to estimate disability prevalence ratios by HIV risk factors.[46] To counteract the lack of independence due to RDS, they clustered on the recruitment chain.[46] They did not share what correlation structure they assumed. They additionally adjusted for network size in order to counteract selection bias caused by individuals in larger social networks being more likely to be recruited from RDS.[46]

A second study used GEE to control for the lack of independence among participants in the injection drug use cycle of NHBS, using a Poisson distribution with GEE clustering on recruitment chain. This study additionally used an exchangeable correlation matrix as GEE allows one to specify the working correlation matrix, which when properly specified, based on knowledge of the population, improves efficiency (i.e., reduces the variance of estimates).[47] Instead of adjusting for network size, this study adjusted for homophily, defined as the tendency of individuals to recruit others with similar characteristics, and the relationship between the recruit and the recruiter.[47] A homophily index continuous variable was created which quantified correlation of specified variables about drug use between the recruiter and recruit.[48,49] The relationship between the recruit and the recruiter was adjusted for by including a variable specifying if the recruiter of the respondent was the primary source of syringes.[46] As we did not include people who inject drugs and did not have information

about the relationship between the respondent and the person who recruited them, we were unable to control for this variable.

Weighting to Account for Lack of Independence between Participants Caused by Respondent Driven Sampling

The other common method used to account for selection bias caused by RDS is weighting. Several publications using NHBS data have accounted for lack of independence between respondents through weighting techniques. One study used two years of each NHBS cycle (MSM, injection drug use, and heterosexually active populations) to assess differences in sample demographics.[50] As the MSM NHBS cycle does not use RDS, the weighting accounted for lack of independence between respondents recruited at the same site through venue based sampling. The authors of this study stated that weighting or another method of controlling for lack of independence is necessary because similarities between respondents who were recruited by the same person or at the same site lead to an underestimation of variances in prevalence estimates, and that sampling behaviors and homophily are not accounted for in a standard regression model not accounting for clustering.[50] This study used the RDS Analysis Tool (RDSAT) which creates weights that adjust for network size, cross-group recruitment probabilities, and group-specific recruitment efficiency.[50–52] Network size refers to the number of individuals the respondent knows that would be eligible to participate in the study. Cross-group recruitment probability refers to the likelihood that someone may have been recruited in another cluster, and group-specific recruitment efficiency refers to how effective recruitment was in sampling the target

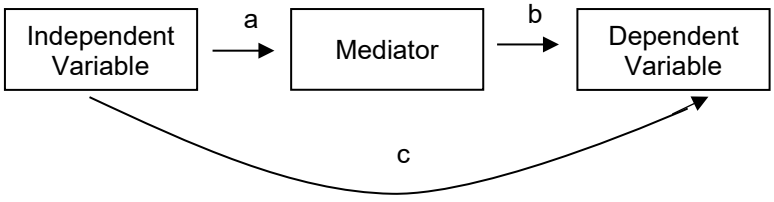
group.[53,54] Using RDSAT, the authors resampled using bootstraps of 15,000 to create adjusted demographic prevalences.[50] They compared these RDSAT adjusted demographic prevalence estimates to the crude demographic prevalence estimates and tested for heterogeneity in the estimates using the Mantel-Haenszel Chi square test for heterogeneity and found that the adjusted and crude estimates did not significantly differ.[50]

RDSAT weighting requires multiple assumptions including the following: 1) respondents accurately report their network size, 2) respondents recruit from their network at random, 3) respondents are just as likely to recruit an individual, as that individual is to recruit the person who recruited them, 4) the further the chain gets from the original respondent, also known as the seed, the more independent the subsequent respondents are from the seed, and 5) sampling is with replacement (which does not occur with RDS as someone cannot be sampled twice) but this assumption considers that individuals may recruit someone almost identical to themselves and that individuals may be capable of recruiting the same people.[53] It is difficult to actually test these assumptions.[55]

Mediation Analysis Methods and its use in Health Research

Bandura's Social Cognitive Theory justifies a mediation analysis, as the relationships between IPV and psychological distress,

Figure 2. Mediation Analysis Effects



Direct Effect: c; Indirect Effect: a + b;
Total Effect: a + b + c

psychological distress and HIV testing, and IPV and HIV testing are interconnected. Mediation analyses are used to better understand a relationship by exploring a possible mechanism, or mediator, that lies along the causal pathway.[56,57] The mediator is explored by breaking the relationship into direct, indirect, and total effects **(Figure 2).**[56,57] The direct effect measures the effect of the independent variable on the dependent variable, not through the mediator.[56,57] The indirect effect is the effect of the independent variable on the dependent variable through the mediator.[56,57] The total effect is the combined effect of the direct and indirect effect.[56,57] Mediation analyses are often used in psychology studies to demonstrate how mental health may mediate health outcomes.

Motivation and Specific Aims

The HIV epidemic among heterosexually active persons in the US is under studied even though heterosexual activity still accounted for 23% of new HIV diagnoses in 2019.[1] The Centers for Disease Control and Prevention (CDC), with the help of state health departments, recruited heterosexually active men and women at high risk for HIV acquisition through respondent-driven sampling (RDS) for in-person interviews as part of the National HIV Behavioral Surveillance (NHBS) in 2016[39,41] Of the 7,453 high-risk heterosexually active persons interviewed in 2016, only 40.7% were tested for HIV in the previous 12 months, respectively.[39] The CDC recommends HIV testing for those aged 13-64 years at least once, and those at higher risk at least once a year.[7] Higher risk was considered as injection-drug users and their sex partners, persons who exchange sex for money or drugs, sex partners of HIV-infected persons, and MSM or heterosexual persons who themselves or whose sex partners have had more than one sex partner since their most recent HIV test.[7] Lack of knowledge of HIV status is detrimental to public health and to the individual, as PLWH who are unaware of their status may unknowingly transmit HIV and are not accessing antiretroviral therapy, leading to increased morbidity and mortality.[8]

A priority of the United States Department of Health and Human services as described in *Ending the HIV Epidemic: A Plan for America* is to reduce HIV incidence by implementing strategies to increase HIV testing and HIV status awareness.[9,10] A previous study using the 2016 NHBS responses found that intimate partner violence (IPV) was associated with lower rates of HIV testing among heterosexually active persons at risk for HIV acquisition.[36] Psychological distress (defined as unpleasant

feelings or emotions that impact an individual's level of functioning) has also been associated with healthcare avoidance, which could include HIV testing.[58] Further defining the relationship between IPV, psychological distress, and HIV testing is needed in order to design and implement effective interventions aimed to increase HIV testing in this population.

Our objective was to use NHBS data from 2016, to assess methods for analyzing survey data with a lack of independence between respondents and to quantify the relationship between IPV, psychological distress, and HIV testing among heterosexually active men and women**.** Controlling for the lack of independence between subjects in survey data generated by RDS (as with NHBS) has been done using weighting and generalized estimating equations (GEE), but comparisons of these methods for analyzing NHBS data has not been performed.[46,47,59,50,60,61] Thus, we had three specific aims:

Aim 1: To compare risk estimates and variance of risk estimates for the association of IPV with psychological distress as well as the bias/precision of the risk estimates through simulations, using both weighting and GEE to control for lack of independence between subjects, using the 2016 NHBS data from Memphis, TN.

Hypothesis 1: The 95% confidence intervals for the risk ratio of IPV on psychological distress would be similar with weighting and GEE, but through simulations varying clustering, GEE will be less biased and more precise than not

accounting for clustering or through using weights as GEE is fairly robust to misspecification of the correlation structure.

Aim 2: To quantify the association between IPV and psychological distress among heterosexually active men and women enrolled in the 2016 NHBS cycles from all 17 participating NHBS sites.

Hypothesis 2: Consistent with previous studies and our preliminary analysis of Memphis, TN NHBS data, IPV will be associated with increased psychological distress among this national heterosexually active population.

Aim 3: To estimate the total, direct and indirect effects of IPV on HIV testing, accounting for psychological distress as a mediator, among heterosexually active men and women enrolled in the 2016 NHBS cycles from all 17 participating sites.

Hypothesis 3: The effect of IPV on HIV testing will be mediated by psychological distress, demonstrating that interventions to improve HIV testing by addressing IPV should also address psychological distress.

We were uniquely positioned to perform this study due to my established collaboration with the Tennessee Department of Health (which supported the NHBS data collection in Memphis, Tennessee). We also assembled a strong team with complementary expertise in mentoring, public health program design, epidemiology, biostatistics, causal inference, as well as intimate partner violence and mental health research to assist in completion of our proposed aims.

We will use the results of this research to inform future studies using NHBS data by determining the best method for controlling for the lack of independence between

respondents created by RDS. Findings from this research will also be used to guide health departments, community-based organizations, and other service providers on whether strategies to improve mental health and HIV testing among heterosexually active men and women at high risk of HIV should focus on individuals experiencing IPV.

II. METHODS TO ACCOUNT FOR LACK OF INDEPENDENCE BETWEEN PARTICIPANTS CAUSED BY RESPONDENT DRIVEN SAMPLING IN NATIONAL HIV BEHAVIORAL SURVEILLANCE STUDIES

Introduction

Memphis, Tennessee had the fifth highest rate of HIV diagnoses in a United States (US) city in 2019 with 23.0 per 100,000 individuals.[62] Surveying individuals at high risk of HIV in the US, particularly in the south, is difficult due to HIV stigma.[63] Thus, use of peer networks for surveillance efforts is necessary to better understand this population.[63,64] National HIV Behavioral Surveillance (NHBS) is an effort conducted by the Centers for Disease Control and Prevention (CDC) in conjunction with local health departments to interview and provide HIV testing in specific high-risk populations in US cities, including Memphis.[65,66] To sample high-risk heterosexual populations, NHBS utilizes respondent driven sampling (RDS). In RDS, participants recruit others within their own networks through dispersal of coupons to individuals in their network who fit the eligibility criteria of the study.[41] RDS creates an issue for analysis though, as most models assume independence between participants, but as respondents are recruiting other respondents, respondents' outcomes may be similar to the outcomes of those who recruited them.[41,42,55]

Generalized estimating equations (GEE) and RDS analysis tool (RDSAT) weighting have been used in previous NHBS studies to account for clustering between subjects.[42,43,46–50,67] Previous studies have compared the results of different RDS weights to one another[55] as well as the results of weighted and unweighted analyses of RDS data[67], but comparison of GEE and RDSAT weighting for analyzing NHBS data

has not been conducted. Using National HIV Behavioral Surveillance (NHBS) data from Memphis, Tennessee in 2016, we assessed the relationship between intimate partner violence (IPV) and psychological distress (PD), comparing GEE and RDSAT-weighted models to each other, and to one that does not account for clustering.

Methods

Study Population

Inclusion criteria for the 2016 heterosexual NHBS cycle consisted of identifying as cisgender man or cisgender woman (nonbinary and transgender individuals were excluded), being 18 - 59 years of age, currently residing in one of the NHBS catchment areas, and being able to communicate in English or Spanish.[65,66] Eligible individuals who provided oral informed consent, also had to report having had vaginal or anal sex with an opposite sex partner in the year before the interview.[55,56] Additionally, for the purpose of our study they had to report being HIV-negative or unsure of their HIV status, as our population of interest is those at high risk for HIV. For this aim, we only used the Memphis, Tennessee sample, as differences in standard error of estimates may be harder to glean with the larger national sample.[68] Of the sites included in NHBS, we focused on Memphis, Tennessee, due to our strong collaboration with the Tennessee Department of Health and because Tennessee was among the ten states with the highest rates of lifetime prevalence of sexual violence, physical violence, and/or stalking victimization by an intimate partner.[69]

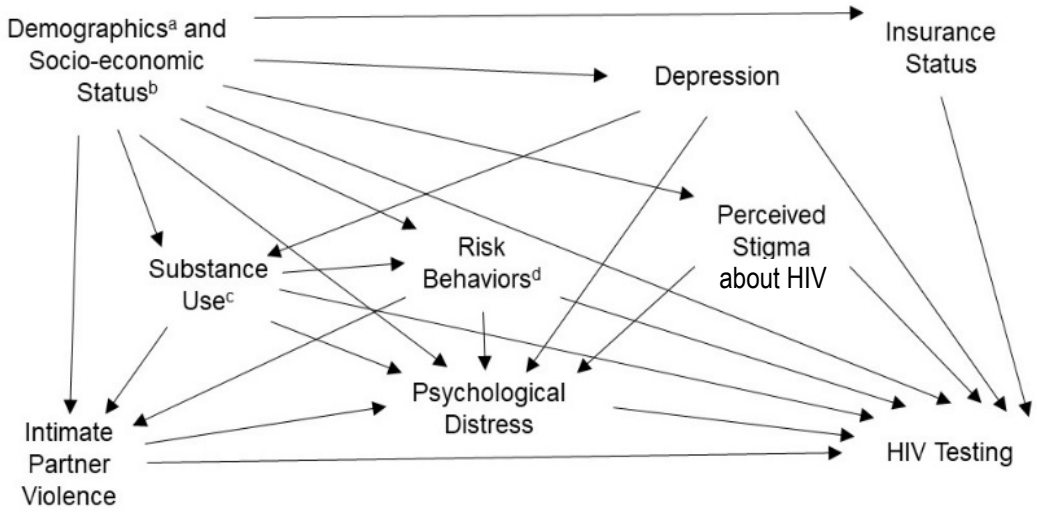
Variable Definitions

Two questions elicited recent IPV victimization: “In the past 12 months, has a partner slapped, punched, shoved, kicked, shaken or otherwise physically hurt you?” and “In the past 12 months, has a partner forced or pressured you to have vaginal, oral or anal sex when you did not want to?”. Victimization was coded as yes if an individual had responded yes to either of the questions and “no” if providing a negative response to both questions. This measure was adapted from items in the 2012 National Intimate Partner and Sexual Violence Survey questionnaire.[65] A thorough description of the development of these survey questions by the CDC can be found in the National Intimate Partner and Sexual Violence Survey state report.[70]

Psychological distress was defined as unpleasant feelings or emotions that impact an individual’s level of functioning and was measured using the Kessler Psychological Distress six-question Scale.[22] A previous study showed that a score of 13 or higher (possible scores range from 0-24) can be used to accurately identify the presence of serious psychological distress.[23] We modeled psychological distress as a dichotomous variable per prior research.[27,29] We assess psychological distress as a continuous measure in later aims, but as the focus of this study is the performance of GEE and RDSAT, we used the validated dichotomous variable. We only looked at the dichotomous variable as our primary analysis in our later aims use the dichotomous version of the variable.

We constructed a directed acyclic graph (DAG) informed by previous research and in consultation with epidemiologists, clinicians, and public health officials who work in the HIV field to determine covariates to include in the adjusted model (**Figure 3**).

Figure 3. Directed Acyclic Graph



a: includes gender, age, race/ethnicity, and marital status
b: includes education and homelessness
c: includes injection drug use and binge drinking
d: includes number of sexual partners in the past year

Covariates included in all models were gender, homelessness, education, marital status, and age. We were unable to include all variables in the adjusted analysis, as with our smaller sample of 543 participants, we would have overfit our model by including all possible covariates. We chose these variables, because we felt they were the most necessary to include to control for confounding, due to likely having a stronger effect on our exposure and outcome than the other possible covariates. Gender identity was a binary variable defined as identifying as either cisgender man or cisgender woman. Homelessness was categorized as currently homeless, homeless in the past 12 months (but not currently), and not homeless in the past 12 months. Homeless was defined as living on the street, in a shelter, in a Single Room Occupancy hotel (SRO), or in a car.[66] Education included three categories: less than high school, finished high school or received a general equivalency diploma, or more than high school. Marital

status was categorized as formerly married/separated, married/cohabitating, and never married. Age at the time of interview (years) was modeled with a restricted cubic spline to relax linear distribution assumptions and to allow model flexibility.[71] The largest subgroup for each variable was used as the reference group to improve statistical stability of the estimates.

Analysis

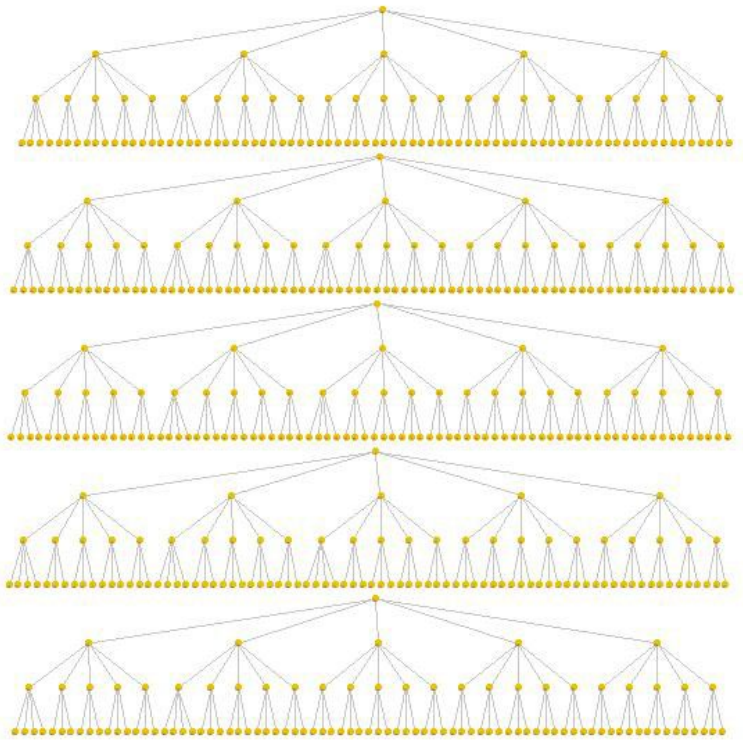
As an example of how different methods may affect real estimates of associations, we assessed the relationship between IPV and psychological distress in the 2016 NHBS population using modified Poisson regression while not accounting for clustering, using GEE to account for clustering, and using weights to account for clustering. We used modified Poisson regression as risk ratios are more easily interpretable than the odds ratios produced by logistic regression, and the robust error variances used for modified Poisson regression creates models that are more likely to converge than other binomial models.[72] We used GEE as it produces marginal estimates, which are more applicable to public health than individual level estimates produced by mixed effects models.[73] For GEE, we used an exchangeable and independence working covariance structures, clustering by recruitment chain determined by codes on coupons used to recruit participants. An exchangeable correlation structure assumes that all observations within a cluster have the same correlation, which differs from RDSAT in that it assumes that individuals have a higher correlation with those closer to them in their recruitment chain (i.e. recruited them or recruited by them).[44,45,53] The correlation assumed by RDSAT can be thought of as autoregressive correlation.[67] A recruitment chain is a group of participants that can all

be traced back to the same initial recruit, or seed. We additionally adjusted for network size, determined by asking how many eligible people the respondent knows and has seen in the past 30 days, to account for likelihood to be recruited.[46] We created weights using RDSAT that adjust for network size, cross-group recruitment probabilities, and group-specific recruitment efficiency, which were defined in the first chapter.[50–52]

In our initial analysis, we compared adjusted risk ratios and the 95% confidence intervals for the association between IPV and psychological distress from analyses not accounting for clustering, using GEE (with exchangeable and independent correlation, adjusting for and not adjusting for network size), and using RDSAT weighting for the 2016 NHBS population. Risk estimates with overlapping 95% confidence intervals were deemed similar. We also assessed the within-cluster correlation from the GEE exchangeable analysis to determine how clustered the data were for the purpose of comparing this value with our simulations to ensure we created an appropriate amount of correlation.

We additionally examined the robustness and validity of these methods by performing a simulation study, simulating data based on an existing dataset in the following six ways: 1) independence between all respondents; 2) moderate exchangeable correlation between respondents within clusters; 3) high exchangeable correlation between respondents within clusters; 4) moderate autoregressive correlation between respondents within clusters; 5) high autoregressive correlation between respondents within clusters; and 6) low autoregressive correlation between respondents within clusters. Settings 2) and 3) simulate data consistent with a GEE analysis approach whereas settings 4)-5) simulate data more consistent with an RDSTAT

analysis approach. We created recruitment trees that started with 5 seeds, that each recruited 5 individuals, then those 25 individuals each recruited 5 individuals, and those 125 individuals recruited either 3 or 4 individuals to bring the total to 543 participants, creating balanced clusters. This simulated recruitment tree can be found in **Figure 4**. We kept the covariates the same as in the observed 2016 data, and simulated the exposure (IPV) based on a predictive model built using the 2016 data including all covariates, but not the outcome, and not accounting for clustering. We then generated a random binomial variable for IPV for each individual based on their fitted probability determined by the predictive model.



The outcome was then simulated depending on the six scenarios mentioned above. First, we fit a predictive modified Poisson model for psychological distress based on IPV and all covariates. We then generated the psychological distress outcome as a random binomial variable from the predictive model, plugging in the randomly generated IPV for that subject. The outcome was generated slightly differently depending on the setting for generating correlation between observations. For scenario 1) independence between all respondents, we simply generated a random binomial variable from the predictive model with no modification. For the exchangeable clustering (scenarios 2-3), we added a cluster-specific random number with a mean of 0 and standard deviation of either 1 (scenario 2) or 2 (scenario 3) to the intercept of the predictive model, and then we simulated the outcome by generating a random binomial variable from this modified predictive model. For the autoregressive correlation scenarios (4-6), we generated a random binomial variable using the same predictive model for the seeds. We then generated the outcome for those recruited by the seeds by adding the difference between the predicted value from the individual that recruited them and 0.5. This random variable had a beta of either 1, 2, or 0.5. We subtracted 0.5 in an attempt to center the results so that the overall prevalence of the outcome was somewhat similar across simulations. We then did this for each individual, basing their outcome off of the outcome of the individual that recruited them.

We ran each simulation 1000 times and compared the values of the mean estimated adjusted risk ratio (ARR), the mean estimated betas (i.e., log ARRs), the standard deviation of the estimated betas, and the mean standard error of the beta estimates. A lower standard deviation of the estimated betas would demonstrate more

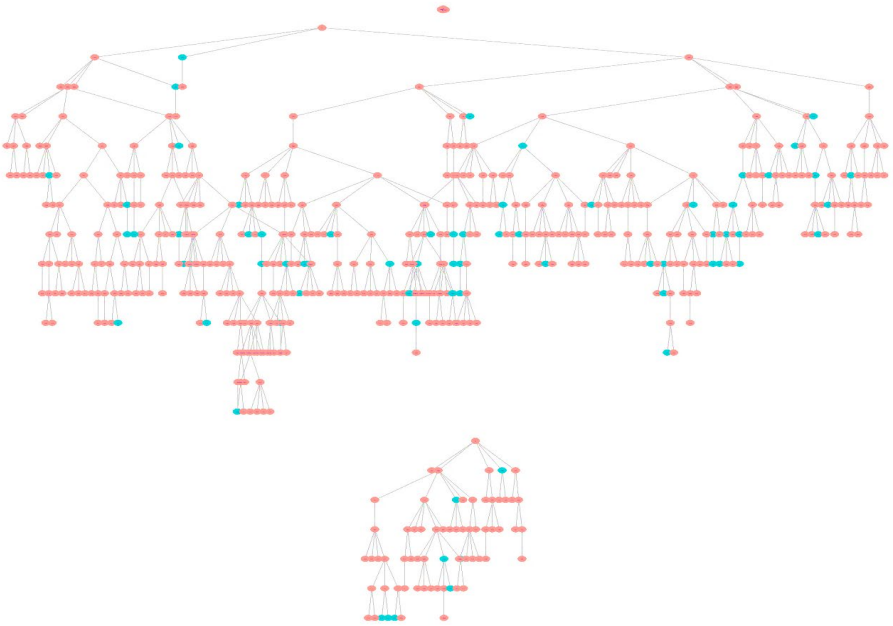
precision. A similar standard deviation of the estimated betas to the mean standard error of the beta estimates would demonstrate valid estimates of variance.[74,75] We also assessed the within-cluster correlation to determine how much correlation within clusters was created by our simulation.

We additionally ran all of these simulations by generating the data in all the same ways, but maintaining the original recruitment tree. As GEE is notorious for performing poorly in populations with few cluster, we created a population where we multiplied the original number of clusters by 5, 10, and 20 then generated the exposure and outcome using the two methods of generating exchangeable data. This allowed us to understand how results produced by these methods may differ for varying sample sizes. For the populations with 10 and 20 times the original population, we only replicated the simulation 200 and 100 times, respectively.

Results

The 2016 NHBS sample had 543 participants. IPV was reported by 69 (12.7%) and psychological distress was reported by 63 (11.6%) participants. This sample had 5 recruitment chains that can be seen in the recruitment tree for participants' experience of IPV (**Figure 5**). The number of respondents per recruitment chain were 1, 1, 1, 68, and 472; note the highly variable number of respondents per chain. The overall distributions for age, race/ethnicity, homelessness, education, marital status, and network size for the can be found in **Table 1**.

Figure 5. Memphis, Tennessee NHBS 2016 Recruitment Tree by Experience of Intimate Partner Violence



- Did Not Experience Intimate Partner Violence
- Experienced Intimate Partner Violence

Table 1. Characteristics of the Individuals Participating in the 2016 Heterosexual Cycles of the National HIV Behavioral Surveillance in Memphis, Tennessee

Characteristic	N (%) or Median (IQR)
Total	543
Intimate Partner Violence	69 (12.7)
Psychological Distress	63 (11.6)
Gender	
Cisgender man	240 (44.2)
Cisgender woman	303 (55.8)
Age	34 (25, 27)
Race/Ethnicity	
White, non-Hispanic	3 (0.55)
Black, non-Hispanic	528 (97.2)
Hispanic	1 (0.2)
Other	11 (2.0)
Homelessness	
Currently homeless	21 (3.9)
Homeless in past 12 months	64 (11.8)
Not homeless in past 12 months	458 (84.4)
Education	
<High School	186 (34.3)
High School or GED	288 (53.0)
>High School	69 (12.7)
Marital Status	
Formerly Married/Separated	81 (14.9)
Married/Cohabitating	87 (16.0)
Never Married	375 (69.1)
Network Size	21 (10, 45)

IQR: Interquartile range
GED: General Equivalency Diploma

IPV victimization was associated with psychological distress according to results from all six forms of analysis (**Table 2**). The modified Poisson regression estimated a similar ARR and 95% CI as the analyses using GEE. RDSAT produced the largest ARR of all the methods and the largest 95% CI (ARR: 4.33, 95% CI: 2.20-8.19). The within-cluster correlation of the original dataset was -0.0019, which demonstrates that there

was almost no correlation between respondents all stemming from the same seed who were likely all in the same network.

Table 2. Adjusted Risk Ratios for the Relationship between Intimate Partner Violence and Psychological Distress among Individuals Participating in the National HIV Behavioral Surveillance in Memphis, Tennessee in 2016

Analysis	ARR (95% CI)
Not Accounting for Clustering	3.78 (2.36-6.06)
Generalized Estimating Equations Exchangeable Correlation with Network Size	3.98 (2.93-5.42)
Generalized Estimating Equations Exchangeable Correlation without Network Size	3.90 (2.80-5.42)
Generalized Estimating Equations Independent Correlation with Network Size	3.86 (3.06-4.87)
Generalized Estimating Equations Independent Correlation without Network Size	3.78 (2.93-4.87)
Respondent Driven Sampling Analysis Tool	4.33 (2.20-8.19)

ARR: Adjusted Risk Ratios
All models adjusted for age, race/ethnicity, homelessness, education, and marital status

Table 3 shows simulation results with the simulated recruitment tree (approximately equal sized clusters). Within each simulation scenario, the mean estimated beta (log ARR) was similar between estimation techniques. In contrast, the standard deviation of the RDSAT estimators was substantially higher than the other estimators. For example, with no clustering, the RDSAT standard deviation was 64% larger than the Poisson model ignoring clustering. The mean RDSAT ARRs were larger, but this is likely due to the larger variance of the betas which would cause the ARRs to be skewed by large values. In almost all scenarios the precision of the estimators using GEE were comparable to the precision of estimators using Poisson regression ignoring clustering. In the scenario where data were simulated with high exchangeable correlation within cluster, GEE using exchangeable working correlation structures

tended to result in estimates with slightly more precision. For scenarios where data were simulated with moderate and high exchangeable correlation, the mean standard error estimate for the beta coefficients for all estimators tended to be substantially smaller than the empirical standard deviation for beta seen in the simulations. This suggests that 95% confidence intervals from these models would be too narrow.

Table 3. Mean Adjusted Risk Ratios (ARR), Mean Betas, Standard Deviations for Betas, and Mean Standard Errors for Betas for Intimate Partner Violence and Psychological Distress for Simulated Recruitment Tree

Simulation Analysis	Mean ARR	Mean Beta	Standard Deviation for Beta	Mean Standard Error for Beta
Independence Between Respondents				
Poisson	4.2418	1.3399	0.46202	0.4317
GEE, exchangeable, network size	4.2972	1.3483	0.47248	0.4132
GEE, exchangeable, no network size	4.2592	1.3429	0.46431	0.4071
GEE, independent, network size	4.2901	1.3479	0.46989	0.4129
GEE, independent, no network size	4.2418	1.3399	0.46202	0.4077
RDSAT	4.9588	1.3367	0.75630	0.5701
Moderate Exchangeable Correlation				
Poisson	3.9532	1.2893	0.4053	0.3495
GEE, exchangeable, network size	3.9168	1.2818	0.3992	0.3023
GEE, exchangeable, no network size	3.8690	1.2719	0.3938	0.2991
GEE, independent, network size	4.0030	1.2992	0.4104	0.3148
GEE, independent, no network size	3.9532	1.2893	0.4053	0.3118
RDSAT	4.4657	1.2981	0.6147	0.4758
High Exchangeable Correlation				
Poisson	2.9314	0.94780	0.4978	0.2664

GEE, exchangeable, network size	2.8266	0.9177	0.4731	0.2552
GEE, exchangeable, no network size	2.7931	0.9127	0.4656	0.2519
GEE, independent, network size	2.9683	0.9530	0.5048	0.2862
GEE, independent, no network size	2.9314	0.9478	0.4978	0.2832
RDSAT	3.1355	0.9341	0.6263	0.3706
Moderate Autoregressive Correlation				
Poisson	3.6990	1.2860	0.2101	0.2071
GEE, exchangeable, network size	3.7477	1.2984	0.2132	0.1993
GEE, exchangeable, no network size	3.7006	1.2861	0.2118	0.1979
GEE, independent, network size	3.7462	1.2984	0.2114	0.1998
GEE, independent, no network size	3.6990	1.2860	0.2101	0.1984
RDSAT	3.9399	1.3129	0.3447	0.2985
High Autoregressive Correlation				
Poisson	3.2375	1.1356	0.2808	0.2639
GEE, exchangeable, network size	3.2439	1.1370	0.2820	0.2565
GEE, exchangeable, no network size	3.2173	1.1297	0.2791	0.2538
GEE, independent, network size	3.2652	1.1433	0.2838	0.2601
GEE, independent, no network size	3.2375	1.1356	0.2808	0.2575
RDSAT	3.4395	1.1353	0.4521	0.3722
Low Autoregressive Correlation				
Poisson	3.8322	1.3261	0.1869	0.1806
GEE, exchangeable, network size	3.8829	1.3386	0.1903	0.1705
GEE, exchangeable, no network size	3.8383	1.3273	0.1886	0.1695
GEE, independent, network size	3.8755	1.3370	0.1884	0.1706
GEE, independent, no network size	3.8322	1.3261	0.1869	0.1697
RDSAT	4.1120	1.3685	0.3039	0.2625

GEE: Generalized Estimating Equations
RDSAT: Respondent Driven Sampling Analysis Tool
All models adjusted for age, race/ethnicity, homelessness, education, and marital status

When conducting the simulations, we assessed the within-cluster correlation for each scenario. Even with forcing clustering, our scenario with the highest within-cluster correlation was with generating high exchangeable correlation (0.2901). The other scenarios generated within-cluster correlations incredibly close to 0, demonstrating that similar to the original data set, there was almost no correlation between individuals who were all connected to the same original seed (**Table 4**).

Table 4. Within-Cluster Correlation of Simulations with a Simulated Recruitment Tree

Simulation	Within-Cluster Correlation
Independence Between Respondents	-0.0017
Moderate Exchangeable Correlation	0.0562
High Exchangeable Correlation	0.2901
Moderate Autoregressive Correlation	0.0013
High Autoregressive Correlation	0.0113
Low Autoregressive Correlation	-0.0003

When data were simulated using the original recruitment tree strategy (**Table 5**), many of the results found in the simulated recruitment chains above were more pronounced. Again, the mean of the beta estimates did not differ between estimators within simulation scenarios. RDSAT estimators tended to be most variable, as seen in their continued production of the largest standard deviation of beta. With these original recruitment trees, though, the mean standard error for all estimators was lower than the standard deviation for all estimators produced by all scenarios. This high difference in the mean standard error and the standard deviation of the estimators was particularly pronounced in the GEE estimates in the high exchangeable correlation scenario. In this

scenario, the standard deviation was almost 4 times larger than the mean standard error. RDSAT also had problems with under-estimating the variance, but not as much as GEE. Incorrectly ignoring the correlation within clusters actually produced standard error estimates closest to the standard deviation, even in situations where there was substantial correlation between individuals all connected to the same original seed.

Table 5. Mean Adjusted Risk Ratios (ARR), Mean Betas, Standard Deviations for Betas, and Mean Standard Errors for Betas for Intimate Partner Violence and Psychological Distress for Original Recruitment Tree

Simulation Analysis	Mean ARR	Mean Beta	Standard Deviation for Beta	Mean Standard Error for Beta
Independence Between Respondents				
Poisson	4.4286	1.3821	0.4875	0.4267
GEE, exchangeable, network size	4.3773	1.3683	0.4899	0.1792
GEE, exchangeable, no network size	4.3438	1.3610	0.4894	0.1765
GEE, independent, network size	4.4784	1.3909	0.4908	0.1938
GEE, independent, no network size	4.4286	1.3821	0.4875	0.1907
RDSAT	5.1549	1.3776	0.7726	0.5673
Moderate Exchangeable Correlation				
Poisson	3.9320	1.3018	0.3585	0.3159
GEE, exchangeable, network size	3.8346	1.2763	0.3706	0.1415
GEE, exchangeable, no network size	3.7994	1.2653	0.3725	0.1416
GEE, independent, network size	3.9797	1.3151	0.3572	0.1287
GEE, independent, no network size	3.9320	1.3018	0.3585	0.1277
RDSAT	4.5623	1.3256	0.6208	0.4255
High Exchangeable Correlation				
Poisson	3.8155	1.2339	0.4517	0.3109

GEE, exchangeable, network size	3.9046	1.2532	0.4652	0.1286
GEE, exchangeable, no network size	3.8206	1.2368	0.4514	0.1278
GEE, independent, network size	3.8960	1.2502	0.4642	0.1110
GEE, independent, no network size	3.8155	1.2339	0.4530	0.1091
RDSAT	4.3314	1.2275	0.6522	0.4115
Moderate Autoregressive Correlation				
Poisson	3.6075	1.2617	0.2068	0.2008
GEE, exchangeable, network size	3.6387	1.2698	0.2093	0.0842
GEE, exchangeable, no network size	3.5951	1.2579	0.2084	0.0836
GEE, independent, network size	3.6510	1.2735	0.2742	0.0900
GEE, independent, no network size	3.6075	1.2617	0.2068	0.0891
RDSAT	3.8468	1.2904	0.3408	0.2887
High Autoregressive Correlation				
Poisson	3.0435	1.0791	0.2600	0.2465
GEE, exchangeable, network size	3.0409	1.0793	0.2562	0.0974
GEE, exchangeable, no network size	3.0207	1.0726	0.2563	0.0967
GEE, independent, network size	3.0644	1.0859	0.2600	0.0992
GEE, independent, no network size	3.0435	1.0791	0.2600	0.0987
RDSAT	3.2035	1.0850	0.4066	0.3463
Low Autoregressive Correlation				
Poisson	3.7934	1.3156	0.1880	0.1799
GEE, exchangeable, network size	3.8220	1.3225	0.1911	0.0766
GEE, exchangeable, no network size	3.7762	1.3108	0.1894	0.0758
GEE, independent, network size	3.8393	1.3273	0.1898	0.0839
GEE, independent, no network size	3.7934	1.3156	0.1880	0.0830
RDSAT	4.0991	1.3658	0.3024	0.2586

GEE: Generalized Estimating Equations
RDSAT: Respondent Driven Sampling Analysis Tool
All models adjusted for age, race/ethnicity, homelessness, education, and marital status

Using the original recruitment tree, the highest within-cluster correlation was still the high exchangeable correlation (0.0322). The second highest was for the moderate exchangeable correlation. All of the within-cluster correlations were fairly close to 0 though, demonstrating that similar to the original data there was almost no correlation between individuals all connected to the same original seed, and therefore all likely in the same social network (**Table 6**).

Table 6. Within-Cluster Correlation of Simulations with the Original Recruitment Tree

Simulation	Within-Cluster Correlation
Independence Between Respondents	0.0041
Moderate Exchangeable Correlation	0.0322
High Exchangeable Correlation	0.0145
Moderate Autoregressive Correlation	-0.0011
High Autoregressive Correlation	-0.0006
Low Autoregressive Correlation	-0.0017

In **Table 7**, where we increased our number of recruitment chains, although the standard error is still lower than the observed standard deviation of beta, the results for the standard deviations and mean standard errors produced by GEE are closer with the larger sample sizes. For example, for high exchangeable correlation in 50 recruitment chains, GEE with an exchangeable correlation structure, and accounting for network size, had a standard deviation of 0.2091 and mean standard error of 0.1543. In contrast, if one ignored the clustering in this scenario, the standard deviation was 0.2499 and the mean standard error was 0.0762. Similarly, standard deviation from RDSAT in this scenario was 0.2780 and the mean standard error was around half this size, 0.1253. As we increased the number of recruitment chains to 100 the mean standard errors from

GEE became closer to the standard deviations, demonstrating that GEE more correctly estimated the variance the larger the population became.

Table 7. Mean Adjusted Risk Ratio (ARR), Mean Betas, Standard Deviations for Betas, and Mean Standard Errors for Betas for Intimate Partner Violence and Psychological Distress for Original Recruitment Tree Multiplied by 5, 10, and 20

Simulation Analysis	Mean ARR	Mean Beta	Standard Deviation for Beta	Mean Standard Error for Beta
Moderate Exchangeable Correlation for 50 Recruitment Chains				
Poisson	3.6955	1.2894	0.1886	0.1529
GEE, exchangeable, network size	3.6521	1.2757	0.1977	0.1529
GEE, exchangeable, no network size	3.6520	1.2756	0.1983	0.1534
GEE, independent, network size	3.7047	1.2919	0.1887	0.1386
GEE, independent, no network size	3.6955	1.2894	0.1886	0.1388
RDSAT	3.8312	1.3007	0.2839	0.2422
High Exchangeable Correlation for 25 Recruitment Chains				
Poisson	2.8059	0.9788	0.3312	0.1141
GEE, exchangeable, network size	2.6266	0.9181	0.3095	0.1716
GEE, exchangeable, no network size	2.6277	0.9183	0.3100	0.1720
GEE, independent, network size	2.8114	0.9805	0.3320	0.1668
GEE, independent, no network size	2.8059	0.9788	0.3312	0.1664
RDSAT	2.8019	0.9649	0.3618	0.1843
Moderate Exchangeable Correlation for 50 Recruitment Chains				
Poisson	3.5779	1.2646	0.1448	0.1058
GEE, exchangeable, network size	3.4800	1.2366	0.1463	0.1173
GEE, exchangeable, no network size	3.4863	1.2384	0.1461	0.1180
GEE, independent, network size	3.5820	1.2657	0.1452	0.1085

GEE, independent, no network size	3.5779	1.2646	0.1448	0.1083
RDSAT	3.6344	1.2720	0.1936	0.1735
High Exchangeable Correlation for 50 Recruitment Chains				
Poisson	2.4601	0.8691	0.2499	0.0762
GEE, exchangeable, network size	2.3039	0.8124	0.2091	0.1543
GEE, exchangeable, no network size	2.3072	0.8135	0.2104	0.1550
GEE, independent, network size	2.4604	0.8692	0.2497	0.1834
GEE, independent, no network size	2.4601	0.8691	0.2499	0.1833
RDSAT	2.4866	0.8722	0.2780	0.1253
Moderate Exchangeable Correlation for 100 Recruitment Chains				
Poisson	3.6024	1.2762	0.1053	0.0738
GEE, exchangeable, network size	3.5018	1.2469	0.1143	0.0930
GEE, exchangeable, no network size	3.5189	1.2515	0.1171	0.0941
GEE, independent, network size	3.6012	1.2759	0.1054	0.0869
GEE, independent, no network size	3.6024	1.2762	0.1053	0.0872
RDSAT	3.6683	1.2876	0.1557	0.1240
High Exchangeable Correlation for 100 Recruitment Chains				
Poisson	2.2951	0.8123	0.1925	0.0530
GEE, exchangeable, network size	2.1753	0.7648	0.1562	0.1208
GEE, exchangeable, no network size	2.1789	0.7659	0.1575	0.1215
GEE, independent, network size	2.2945	0.8120	0.1926	0.1568
GEE, independent, no network size	2.2951	0.8123	0.1925	0.1568
RDSAT	2.2523	0.7921	0.1993	0.0886

When multiplying the original recruitment trees by 5, 10, and 20, the largest within-cluster correlations were among the high exchangeable correlation scenarios and the within-cluster correlation increased as we increased the number of recruitment chains (**Table 8**). Multiplying by 20 had the largest within-cluster correlation (0.4106),

showing that with more seeds and recruitment chains, the similarities between individuals all connected to the same original seed and in the same recruitment chain, became more pronounced.

Table 8. Within-Cluster Correlation of Simulations with the Original Recruitment Tree Multiplied by 5 and 10

Simulation	Within-Cluster Correlation
Moderate Exchangeable Correlation for 25 Recruitment Chains	0.0563
High Exchangeable Correlation for 25 Recruitment Chains	0.2545
Moderate Exchangeable Correlation for 50 Recruitment Chains	0.0721
High Exchangeable Correlation for 50 Recruitment Chains	0.3639
Moderate Exchangeable Correlation for 100 Recruitment Chains	0.0758
High Exchangeable Correlation for 100 Recruitment Chains	0.4106

Discussion

Our simulations based off of the 2016 NHBS heterosexually active individuals at high risk for HIV in Memphis, Tennessee revealed that RDSAT consistently produces larger standard deviations for beta and mean standard errors for beta than GEE and a Poisson model not accounting for clustering. All analyses appeared to underestimate the variance of the relationship between IPV and psychological distress. With a simulated and extremely balanced recruitment tree, RDSAT, seemed to underestimate the variance the most, and with the unbalanced recruitment tree, GEE, appeared to underestimate the variance the most. When increasing the number of recruitment chains, the GEE model appeared to produce the closest mean standard errors to the estimated standard deviations. In balanced data with few clusters, GEE appears to be the better option because it produces more precise estimates than the other methods. In unbalanced data with few clusters, not accounting for clustering may be the best

option, as GEE produces inappropriately small variance estimates and RDSAT weighting produces less precise data and seemingly inflated ARRs. In unbalanced data with many clusters, GEE appears to perform the best due to more precise estimates and correct estimation of variance.

Our simulations were based on the Memphis, Tennessee NHBS data from the 2016 population, which had psychological distress reported by 15.1% of participants and experience of IPV was reported by 12.7% of participants. We found an association between IPV and psychological distress using all six methods. The RDSAT analysis provided a higher point estimate for the relationship, and had a much larger range for the 95% confidence interval showing that this was a less precise estimate as compared to the method not accounting for clustering and GEE. The smallest range for the 95% confidence intervals were from the GEE analyses, specifically the GEE analysis with an independent correlation accounting for network size, showing that GEE offered a more precise estimate than the RDSAT analysis and the analysis not accounting for clustering.

When simulating data based on the Memphis, Tennessee NHBS data and creating new, balanced recruitment trees, the betas produced by the six different methods of analyses did not differ meaningfully with scenarios creating different types of clustering. These similarities are likely due to the fairly similar within-correlation clustering created by each of our scenarios. RDSAT produced larger mean ARRs in all scenarios, which was likely due to the larger variance in beta estimates. A previous study found RDSAT weights often lead to a large bias in estimates in respondent-driven collected samples as compared to unweighted data.[67] Our findings support these

findings, but offer an explanation for why ARRs produced by RDSAT weights appear to be biased.

In the balanced clusters, RDSAT also tended to produce the largest standard deviations and mean standard errors, demonstrating that RDSAT produced the least precise estimates, which was also seen in the original data. GEE and not accounting for clustering produced very similarly precise estimates, but GEE consistently had the lowest standard errors. Using independent or exchangeable correlation did not appear to meaningfully affect the results, which reinforces the idea that GEE is fairly robust to misspecification of the correlation structure.[45] All of these models appeared to underestimate the variance in the relationship between IPV and psychological distress, but RDSAT seemed to perform the worst in regards to estimating the variance in balanced clusters, unlike in unbalanced clusters where GEE seems to perform the worst.

When using the original, unbalanced trees, the within-cluster correlations were lower than in the balanced samples. These differences are likely due to the fact, that we were attempting to generate correlation between individuals all connected to the same original seed, as this is the reason why we have to employ these methods to account for lack of independence between individuals. Based on our estimates of within-cluster correlation, the simulations that were supposed to have higher clustering, based on how we generated the data, did have appropriately higher within-cluster correlations.

Results from simulations with unbalanced recruitment trees were very similar to results from simulations with balanced recruitment trees. RDSAT still produced larger standard deviations and mean standard errors. The different specifications of GEE in

simulations with unbalanced recruitment trees also produced similar results to the balanced recruitment tree simulations. GEE and analyses not accounting for clustering were once again very similar in ARRs and standard deviations for simulations with unbalanced trees, but GEE had lower mean standard errors. In unbalanced trees, GEE seemed to produce standard errors that are likely incorrectly small, as the variance estimated by GEE was much smaller than the actual variance of the beta estimates produced in simulations using GEE. Findings that GEE often underestimates the variance of estimates in samples with a small number of clusters, such as in this data with only 5 clusters, is consistent with previous studies.[76] Previous studies have determined too few clusters for a GEE analysis is < 15 clusters.[77] This underestimation did not appear until the clusters were unbalanced, though.

When we multiplied the population by 5, 10, and 20 and used an exchangeable correlation structure, once again RDSAT still produced the largest standard deviations of beta and mean standard errors, showing that RDSAT is still the least precise. The major difference in the simulation results seen by increasing the number of recruitment chains, were that RDSAT and ignoring clustering now underestimated the variance the most. Now that there was stronger clustering, as seen in our higher within-cluster correlations, not accounting for this clustering was a larger issue. GEE with an exchangeable correlation structure, accounting for network size produced the most accurate estimate of variance in the more strongly clustered simulations. In a population with a sufficiently large number of recruitment chains, such as our simulations with 25, 50, and 100 recruitment chains, GEE performs the best with regards to precision of estimates and correct assessment of variance.

Limitations of our study arise from our selections in how we simulated the data. We attempted to make the data as similar to NHBS data as possible, by basing our simulations on actual NHBS data from Memphis, Tennessee. However, other RDS collected samples collected by surveys other than NHBS, or other NHBS surveys from other cities may differ from the one used to simulate our data. Additionally, we chose to focus on how clusters may vary as opposed to focusing on how the individuals sampled may differ, because RDS is highly unpredictable in how recruitment chains may propagate. However, there are other aspects of RDS samples that could be assessed in future simulation studies such as proper estimation of network size, but to assess these we would most likely compare responses to different questions in the survey.

Conclusions

Based on our simulation study comparing the methods of RDSAT weighting and GEE for analyzing NHBS data, beta estimates were incredibly similar for RDSAT weighting, GEE, and not accounting for clustering. Differences between these methods were mostly seen in the estimates of variance. GEE consistently provided more precise estimates with lower standard deviations and mean standard errors. However, in an unbalanced dataset, GEE produced incorrectly small standard errors. When increasing the number of recruitment chains in an unbalanced sample, GEE, most correctly estimated the variance in the relationship between IPV and psychological distress. Correct estimation of the variance is possibly the most important metric under our consideration, because when underestimating variance, we may declare an association significant when it really is not. When analyzing RDS data, careful attention should be

paid to the structure of the recruitment trees, the number of clusters, and the correlation within clusters. In balanced data with few clusters, GEE should be utilized, because it produces more precise estimates than the other methods. In unbalanced data with few clusters, not accounting for clustering may be the preferred method, as RDSAT weighting produces less precise point estimates and seemingly inflated ARRs and GEE greatly underestimates the variance. In unbalanced data with many clusters, GEE appears to perform the best due to its production of the most precise estimates and most correct variance. As the population utilized in our later aims has 95 clusters, we decided that GEE with an exchangeable working correlation structure accounting for network size would be the best method to use, as it provides the most precise estimates and most correctly approximates the variance in a population with a large number of unbalanced clusters.

III. THE RELATIONSHIP BETWEEN INTIMATE PARTNER VIOLENCE AND PSYCHOLOGICAL DISTRESS AMONG HETEROSEXUALLY ACTIVE MEN AND WOMEN AT HIGH RISK OF HIV INFECTION

Introduction

Intimate partner violence (IPV) in the form of sexual violence, physical violence, and/or stalking by an intimate partner has affected 43.6 million (36.4%) United States (US) women and 37.3 million (33.6%) US men in their lifetime.[69] The experience of IPV has been shown to lead to physical injury in 25.1% of US women and 10.9% of US men and is associated with chronic health conditions, such as chronic pain, fainting, seizures, and even death.[17,69] During the COVID-19 pandemic, IPV has increased as tensions between partners quarantining together have increased, and individuals are forced to quarantine in their homes with a violent partner.[19–21] With IPV increasing, understanding the possible mental health effects of IPV is important.

Psychological distress (PD), is a precursor for mental health disorders, such as anxiety and depression, and screening for PD could be a strategy to identify individuals in need of further mental health resources prior to their development of clinical mental health diagnoses.[22] Psychological distress is a practical measure for determining the need for further screening of mental health disorders because it can be identified through 6 simple survey items.[22] Psychological distress, on its own, has also been shown to lead to healthcare avoidance and subsequent poor health outcomes, and psychological distress has also increased during the COVID-19 pandemic.[24,58]

Both IPV and psychological distress are more common among people living with HIV, but IPV and psychological distress have been understudied among those at risk of

and not currently living with diagnosed HIV infection.[28,31] IPV and psychological distress are likely to be more common among this population as compared to the general population, as factors associated with being at risk of an HIV diagnosis are similar to factors associated with IPV and psychological distress.[78–80] Additionally, experiencing IPV has been shown to be associated with psychological distress, but studies exploring this association are older, have rarely included men despite the experience of IPV among men, and have not assessed the relationship between IPV and psychological distress among people at increased risk of HIV who may be at higher risk for IPV and psychological distress as compared to the general population.[25–27] To address these gaps in knowledge, we assessed the relationship between IPV and psychological distress among heterosexually active men and women from all sites in the 2016 National HIV Behavioral Surveillance (NHBS) cycle.

Methods

Sample Population

We used the 2016 and NHBS heterosexual cycle data including all 17 sites: Atlanta, Georgia; Boston, Massachusetts; Dallas, Texas; Denver, Colorado; Los Angeles, California; Memphis, Tennessee; Miami, Florida; Nassau-Suffolk, New York; New Orleans, Louisiana; Newark, New Jersey; Philadelphia, Pennsylvania; Portland, Oregon; San Diego, California; San Francisco, California; San Juan, Puerto Rico; Virginia Beach, Virginia; and Washington, DC.[39] Inclusion and exclusion criteria were identical across all NHBS sites and consisted of identifying as cisgender man or cisgender woman (nonbinary and transgender individuals were excluded), being 18 - 59 years of age, currently residing in one of the NHBS catchment areas, and being able to

communicate in English or Spanish.[65,66] Eligible individuals who provided oral informed consent, also had to report having had vaginal or anal sex with an opposite sex partner in the year before the interview.[55,56] Additionally, for the purpose of our study they had to report being HIV-negative or unsure of their HIV status as our population was those at high-risk of HIV, and for this analysis, we additionally excluded individuals missing data for any of the variables included in the multivariable model, as there was very little missing data (0.4% participants).

Variable Definitions

IPV, psychological distress, gender, age, homelessness, education, marital status, and network size were assessed using the same variables described in the methods section of the previous chapter. We wished to include more covariates in the simulation aim, but were unable to due to the smaller sample size. In this second aim, we included race/ethnicity, US census region, number of sexual partners in the past year, binge drinking, injection drug use, and non-injection drug use as additional covariates that were not included in the first chapter. Race/ethnicity was categorized as White, non-Hispanic; Black, non-Hispanic; Hispanic; and other. US Census Regions were categorized as Northeast, South, Midwest, West, and US Territories based on the regions established in the US Census.[81] Sex partners in the past year was asked in an open manner, but to maintain consistency with CDC reports, we categorized this variable into 0-1, 2-5, 6-10, and >10 partners. Binge drinking was defined as >5 drinks for men and >4 drinks for women in one sitting within the past 30 days and is modeled as a binary variable. This definition of binge drinking has been validated as part of the Alcohol Use Disorders Identification Test (AUDIT-C).[65,66,82] Injection drug use was also

binary, categorized as ever injected any drugs not prescribed to you or never injected drugs. Non-injection drug use was binary, with an answer of yes or no when asked if the respondent used any drugs not prescribed that were not injected in the past 12 months.

Analysis

We used modified Poisson regression with GEE and an exchangeable working correlation structure clustering by recruitment chain to account for lack of independence between participants as it seemed to produce the most precise estimates and most correctly estimate the variance in a population with more clusters. We assessed the relationship between the exposure of any type of IPV and the outcome of psychological distress in the full NHBS data from the 2016 cycle. We additionally assessed IPV as physical and sexual violence, separately, as physical and sexual violence may affect a person's mental health differently. Analyses were also stratified by gender identity to account for gender identity as a potential effect modifier of the association between IPV and psychological distress. This relationship has been understudied in men and we believe the effect of IPV on psychological distress may differ by gender as other effects of IPV have been more severe among women.[83] A Wald homogeneity test with a conservative significance level of p=0.20, as suggested by Rothman, Greenland, and Lash, was used to determine if the association of IPV with psychological distress was statistically different following stratification by gender identity.[84,85] We additionally conducted a sensitivity analysis where our outcome of psychological distress was measured as a continuous Kessler Scale score rather than the binary variable used in the primary analysis as dichotomization could lead to loss of information.[86] We still used

a Poisson model as the Kessler Scale was an integer score, and therefore appropriate for a Poisson regression analysis. We conducted a secondary analysis using the 2019 NHBS data, as the 2016 data was older. However, the 2019 NHBS data measured physical and sexual violence, without specifying that the violence was perpetrated by an intimate partner. The 2019 sample additionally differed in that there were 6 other sites included, and people who inject drugs were not included. All the same analyses were conducted in the 2019 data, but assessing general violence rather than IPV, and the results of this secondary analysis are summarized in **Appendix A**. We have decided to keep these analyses separate, as IPV and general violence are measuring different experiences, and the populations in the 2016 and 2019 cycles include different participants , making comparisons inappropriate.

Results

NHBS surveyed 8,078 participants in 2016. More cisgender women participated than men with 4,248 (52.6%) identifying as women. The majority of the sample (71.2%) was Black, non-Hispanic (**Table 9**). Overall, 1,169 participants (14.5%) were currently homeless, 4,295 (53.2%) had a high school education or GED, 5,159 (63.9%) were never married, 3,741 (46.3%) had 2-5 sexual partners in the past 12 months, 2,931 (36.3%) reported binge drinking in the past 30 days, 455 (5.6%) reported injecting drugs in the past year, 4,675 (57.9%) reported using non-injection drugs in the past year, and the median network size was 30 (IQR 15-60).

Table 9. Characteristics of the Individuals Participating in the 2016 Heterosexual Cycle of the National HIV Behavioral Surveillance

Characteristic	N (%) or Median (IQR)
Total	8,078
Gender	
Cisgender man	3,830 (47.4)
Cisgender woman	4,248 (52.6)
Age (years)	36 (27, 50)
Race/Ethnicity	
White, non-Hispanic	299 (3.7)
Black, non-Hispanic	5,750 (71.2)
Hispanic	1,620 (20.1)
Other	394 (4.9)
Missing	15 (0.2)
Homelessness	
Currently homeless	1,169 (14.5)
Homeless in past 12 months	994 (12.3)
Not homeless in past 12 months	5,914 (73.2)
Missing	1 (0.0)
Education	
<High School	2,374 (29.4)
High School or GED	4,295 (53.2)
>High School	1,409 (17.4)
Marital Status	
Formerly Married/Separated	1,562 (19.3)
Married/Cohabitating	1,357 (16.8)
Never Married	5,159 (63.9)
Missing	0 (0.0)
Sex Partners in the Past 12 months	
0-1 partners	2,858 (35.4)
2-5 partners	3,741 (46.3)
6-10 partners	859 (10.6)
>10 partners	620 (7.7)
Region	
Northeast	1,886 (23.3)
South	3,519 (43.6)
Midwest	0 (0.0)
West	2,154 (26.7)
Territories	519 (6.4)
Binge Drinking	2,931 (36.3)

Missing	15 (0.2)
Injection Drug Use	455 (5.6)
Non-Injection Drug Use	4,675 (57.9)
Network Size	30 (15, 60)
Missing	3 (0.0)

IQR: Interquartile range
GED: General Equivalency Diploma

Overall, 1,443 (17.9%) participants experienced psychological distress (**Table 10**). More women experienced psychological distress (22.1%) than men (13.2%) (p<0.01). Experience of any IPV type was reported by 1,385 (17.1%) participants, physical IPV by 1,054 (13.0%), and sexual IPV by 628 (7.8%). There were no differences in overall IPV experience (p=0.98), physical IPV experience (p=0.24), or sexual IPV experience (p=0.47) by gender.

Table 10. Severe Psychological Distress and Intimate Partner Violence by Gender

	Combined (N=8,078)	**Women (N=4,248)**	**Men (N=3,830)**	**P-value***
Severe Psychological Distress[a]	1,443 (17.9%)	939 (22.1%)	504 (13.2%)	<0.01
Experienced Intimate Partner Violence	1,385 (17.1%)	728 (17.1%)	657 (17.2%)	0.98
Experienced Physical Violence	1,054 (13.0%)	572 (13.5%)	482 (12.6%)	0.24
Experienced Sexual Violence	628 (7.8%)	339 (8.0%)	289 (7.5%)	0.47

* p-value determined through clustered chi-square test comparing men and women
a: Measured using the Kessler scale with a cutoff of ≥13

Estimates from multivariable regression models suggested that severe psychological distress was independently associated with all types of IPV (**Table 11**). For example, experience any type of IPV was associated with psychological distress (ARR: 1.92; 95% CI: 1.75-2.12).

Table 11. Adjusted* Risk Ratios (ARR) and 95% Confidence Intervals (CI) for Types of Intimate Partner Violence and Psychological Distress

	ARR (95% CI)
Experienced Intimate Partner Violence	1.92 (1.75-2.12)
Experienced Physical Violence	1.89 (1.70-2.10)
Experienced Sexual Violence	1.80 (1.67-1.94)

*all models adjusted for gender, age, housing, education, marital status, binge drinking, non-injection drug use, region, network size, and injection drug use

Based on our conservative p<0.20 cutoff to determine effect measure modification, the relationship between experience of any, physical, and sexual IPV and psychological distress did not differ by gender (**Table 12**).

Table 12. Adjusted* Risk Ratios (ARR) and 95% Confidence Intervals (CI) for Partner Violence and Psychological Distress Stratified by Gender

	Men ARR (95% CI)	Women ARR (95% CI)	p-value [a]
Experienced Intimate Partner Violence	2.08 (1.71-2.52)	1.82 (1.63-2.03)	0.26
Experienced Physical Violence	2.05 (1.72-2.44)	1.81 (1.61-2.04)	0.28
Experienced Sexual Violence	1.82 (1.50-2.21)	1.75 (1.57-1.95)	0.59

*all models adjusted for gender, age, housing, education, marital status, binge drinking, non-injection drug use, region, network size, and injection drug use
a: p-value for Wald Homogeneity test assessing effect modification by gender. A p-value <0.2 was considered significant.

Our sensitivity analysis, assessing psychological distress as a continuous outcome, rather than the dichotomous variable used in the primary analysis, provided point estimates in the same direction as the primary analysis of the relationship between any IPV and psychological distress (**Table 13**). Holding all other variables constant, individuals who experienced IPV had a mean psychological distress Kessler score that was 1.34 (95% CI: 1.29-1.38) times higher than those without IPV experience.

Table 13. Adjusted* Point Estimates and 95% Confidence Intervals (CI) for the Relationship between Intimate Partner Violence and Psychological Distress Measured as a Dichotomous Variable or as a Score

Outcome Definition	Adjusted Point Estimates (95% CI)
Experienced Psychological Distress (Dichotomous)	ARR: 1.92 (1.75-2.12)
Kessler Psychological Distress Score	Ratio of Means: 1.34 (1.29-1.38)

*all models adjusted for gender, age, housing, education, marital status, binge drinking, non-injection drug use, region, network size, and injection drug use

Discussion

Among the 8,078 participants surveyed in 2016, experience of any IPV was associated with severe psychological distress. Psychological distress was much more common among the NHBS sample in comparison to the general US population in 2018 in which 3.9% of US adults experienced psychological distress whereas 17.9% of our sample experienced psychological distress.[24] The higher proportion of psychological distress among the national NHBS population as compared to the general population could be associated with study eligibility. To participate in NHBS, individuals had to be at increased risk for HIV as determined by living in areas where HIV is prevalent, and by having a lower economic status, which could also increase the risk of experiencing

psychological distress.[87] As psychological distress is more common among the heterosexually active cycle of NHBS as compared to the general US population, perhaps future NHBS efforts should further investigate clinical mental health disorders, such as depression and anxiety, and provide resources or referrals to resources to address mental health disorders in this population.

Experience of IPV was also more common among the 2016 national NHBS sample as compared to the general US population. The most recent National Intimate Partner and Sexual Violence Survey from 2015 found that 5.2% of men and 5.5% of women in the United States experienced any IPV in the 12 months preceding the survey.[69] Our findings were similar to these findings in that any IPV experience did not significantly differ between men and women, with 17.1% of women and 17.2% of men experiencing any IPV. A lack of difference between men and women was still seen when separating types of IPV into physical and sexual violence with 13.5 % of women and 12.6% of men experiencing physical IPV and 8.0% of women and 7.5% of men experiencing sexual IPV. These findings reinforce the need to include men and women in research on IPV. IPV may be more common among heterosexually active individuals at high risk for HIV as compared to the general US population, because of the sociodemographic characteristics of those with high HIV risk, such as low income, which is also associated with severe psychological distress and IPV.[31,78,87–89]

In the national NHBS population of heterosexually active individuals at high risk of HIV, any IPV was strongly associated with psychological distress in 2016 in that someone experiencing any IPV was almost twice as likely to experience severe psychological distress. These findings were consistent with our findings in the Memphis,

Tennessee sample of NHBS as seen in the first aim, as well as previous studies in other populations of US men and women that found IPV was associated with psychological distress.[26,27,90,91] However, the only previous studies that assessed this relationship in men and women (versus women only) were conducted over 10 years ago; and one more recent study was conducted only among young couples.[26,27,90,91] Therefore, our findings build upon previous studies by including heterosexual individuals who have an intimate partner but may not be in a relationship, and focusing on heterosexually active individuals at risk of HIV, as this population may be at higher risk for both IPV and psychological distress.[26,27,90,91] These older studies additionally separated physical and sexual violence as well as assessing any IPV and similarly found all types of violence to be associated with psychological distress, showing that although our population of heterosexually active men and women at high risk of HIV may differ in the prevalence of different types of IPV, all types of IPV are still strongly associated with psychological distress.[26,27,90,91]

These older studies also found that for all relationships between different types of IPV and psychological distress, women had a stronger association between IPV and psychological distress compared to men.[26,27,90,91] We did not find a difference in the relationship between sexual violence and psychological distress when stratifying by gender. As both men and women in our study are experiencing sexual IPV and psychological distress at similar proportions, these findings further justify a need to continue assessing the relationship between IPV and psychological distress among both men and women.

As a sensitivity analysis, we assessed our outcome of psychological distress as a continuous Kessler score, as dichotomizing this variable could lead to a loss of information.[86] We still found that IPV was associated with psychological distress. However, by using the continuous score we are measuring the association with increasing psychological distress score, and not with severe psychological distress. The dichotomous score for severe psychological distress is the measure used in other studies, as this is how this tool has been validated. So, although we may be losing information by dichotomizing, this allows us to better compare our results to other studies and did not meaningfully change our conclusions.

We encountered some limitations in this research. First, data were self-reported to an interviewer, which could lead to social desirability bias and the underreporting of IPV.[92] The interviewers tried to account for this by allowing the interview to be anonymous, in that no identifying information was obtained. A second potential limitation is volunteer bias in that those who agreed to be interviewed may differ from those who did not.[93] Although offering compensation may bias enrollment toward those of low socioeconomic status, this bias was deemed appropriate, as the study was intended to include those at higher risk of HIV, and CDC surveillance has shown that HIV is more common among those of low socioeconomic status.[62] The CDC additionally attempted to diminish volunteer bias through using community organizations identified by the state health department as being important to the community and respondent driven sampling to recruit individuals that otherwise may not have participated in a study conducted by the CDC or their local health department. A third limitation is inherent with the use of non-randomized samples in that there may be

unmeasured confounders that could bias inferences. A fourth limitation is that although this is a multi-site study, no sites were located in the midwestern US, limiting the generalizability to that US region.

Conclusion

Among heterosexually active, cisgender men and women at high risk for HIV infection participating in NHBS in 2016, experiencing IPV was associated with psychological distress. Reported experience of IPV did not differ among men and women, highlighting the need to include both men and women in future studies. Women were more likely to report severe psychological distress as compared to men, highlighting the need to continue stratifying by gender in studies on psychological distress, as gender may be an effect measure modifier in other relationships involving psychological distress. Overall, there was a high prevalence of severe psychological distress demonstrating a potential for a subsequent higher rate of mental health disorders in this population. This highlights the need to increase psychological distress screening among heterosexually active men and women at increased risk of HIV in order to improve the mental health of this population, regardless of experience of IPV. Experiencing IPV was associated with an increased risk of severe psychological distress demonstrating the need for increased screening for psychological distress in those experiencing IPV if resources are limited. Partnering with community-based organizations addressing IPV for psychological distress screening may be more feasible, from a public health standpoint, then trying to screen the general population of heterosexually active men and women at high risk of HIV. The relationship between any IPV and severe psychological distress did not differ by gender, demonstrating the

importance of including men in research on experience of IPV and severe psychological distress and providing mental health services for both men and women experiencing IPV.

IV. ASSESSING PSYCHOLOGICAL DISTRESS AS A POSSIBLE MEDIATOR IN THE RELATIONSHIP BETWEEN INTIMATE PARTNER VIOLENCE AND HIV TESTING AMONG HETEROSEXUALLY ACTIVE MEN AND WOMEN AT HIGH RISK OF HIV INFECTION

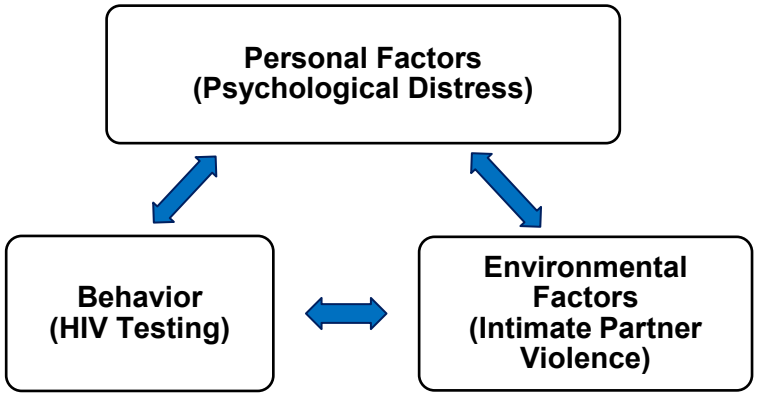
Introduction

Over 1 million people are estimated to be living with either diagnosed or undiagnosed HIV in the United States, and 37,968 people were newly diagnosed in 2018.[80] Of those newly diagnosed, 24% were attributed to heterosexual contact.[80] Although HIV is less common among heterosexuals living in the US compared to other HIV risk groups, the highest rate of undiagnosed HIV in the US is estimated to occur among men with transmission attributed to heterosexual contact (18.4%), as compared to MSM (16.4%), and women with transmission attributed to heterosexual contact (12.7%). This is likely due to perceived risk of HIV being higher among MSM as compared to heterosexually active men and women.[3,4] The lower rates of undiagnosed HIV in women is likely due to the recommendation for opt-out HIV testing among pregnant women.[7]

Increasing HIV testing is a primary goal of the United States Ending the HIV Epidemic plan, as HIV diagnosis allows individuals to link to HIV care and subsequently decrease HIV transmission and mortality.[9,10] As HIV testing is a health behavior, the Social Cognitive Theory proposed by Albert Bandura, can be used in understanding ways to modify this behavior.[11] Bandura theorized that to change a behavior, one must acknowledge the personal and environmental factors that may affect each other in addition to the health behavior of interest (**Figure 6**).[11] Previous studies have found

evidence of associations between psychological distress and IPV, psychological distress and HIV testing, and IPV and HIV testing. However, these studies have not assessed the way these factors may be interconnected and have not assessed these relationships among both heterosexually active men and women at high risk for HIV in a multi-site study.[25–29,34–38] Thus, we conducted a mediation analysis assessing the relationship between IPV and HIV testing accounting for psychological distress as a possible mediator among the National HIV Behavioral Surveillance 2016 heterosexual data collection cycle.

Figure 6. Model of Social Cognitive Theory for Intimate Partner Violence, Psychological Distress, and HIV Testing



Methods

Study Population

We used data from the same 2016 NHBS sample of heterosexually active individuals at high risk of HIV infection that was used in the second aim of this research. All of the same sites and eligibility criteria were utilized. There were no missing data for

HIV testing history, so there were no additional individuals excluded by adding this variable to our analyses.

Variable Definitions

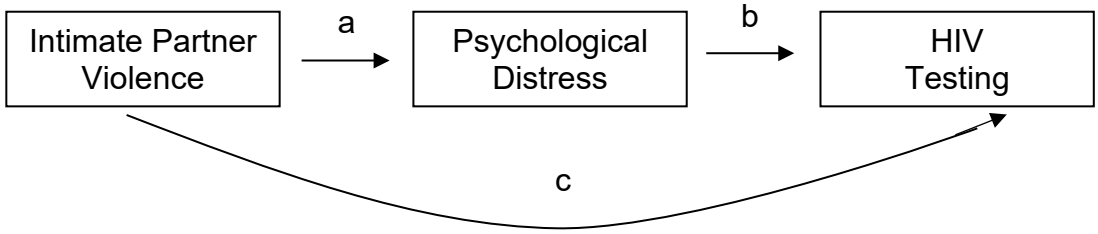
As we used the same data sources as in Aim 2, the definitions of the primary variables of interest and covariates are the same. All models included gender, age, homelessness, education, marital status, and network size, number of sexual partners in the past year, US census region, binge drinking, injection drug use, and non-injection drug use. We additionally assessed HIV testing in this third aim. HIV testing was assessed using the following "yes" or "no" question: "Was your most recent HIV test in the past 12 months?". To maintain consistency with our other two variables (IPV and psychological distress) being negative outcomes, we reverse coded this variable to be no HIV testing in the past 12 months. This means that we interpreted an adjusted risk ratio (ARR) of >1 as more likely not to have tested for HIV in the past 12 months and <1 as less likely not to have tested for HIV in the past 12 months.

Analysis

We attempted to assess the natural direct and indirect effect of IPV on HIV testing in addition to the effect of IPV on HIV testing mediated by psychological distress (**Figure 7**). We used modified Poisson regression and GEE with an exchangeable working correlation, clustering on recruitment chain to control for lack of independence between respondents for the 2016 cycle of NHBS. We used GEE with an exchangeable working correlation, as this method produced the most precise estimates with the most correctly estimated variance based on our simulation study. We used the difference method, as it provides conservative and straightforward estimates for mediation, and a

data duplication algorithm outlined by Nevo, Liao and Spiegelman to determine natural direct and indirect effects.[94,95] The natural direct effect quantifies the effect IPV has on HIV testing not mediated through psychological distress, the natural indirect effect quantifies the effect of IPV on HIV testing that arises from IPV affecting psychological distress, which then affects HIV testing, and the total effect is the full effect of IPV on HIV testing both mediated by psychological distress and not mediated by psychological distress.[56,94,96] A simplified DAG is included in **Figure 7**, to demonstrate the hypothesized relationship between IPV, psychological distress, and HIV testing and which relationships correspond to the direct, indirect, and total effects.

Figure 7. Simplified Directed Acyclic Graph



Direct Effect: c; Indirect Effect: a + b; Total Effect: a + b + c

We hypothesized that the effect of IPV on HIV testing would be mediated by psychological distress, due to the previously established relationships between IPV and psychological distress, psychological distress and HIV testing, and IPV and HIV testing.[26–28,28,35,38,91]

We additionally separated IPV type into sexual and physical violence to see if these relationships differ by IPV type. If psychological distress was a mediator, determined by a significant direct and indirect effect, we planned to report the proportion

of the total effect mediated by psychological distress. If psychological distress was not determined to be a mediator, we planned to assess the individual relationships between IPV and HIV testing, IPV and psychological distress, and IPV and HIV testing. We assessed all relationships using a modified Poisson regression and GEE with an exchangeable working correlation structure, clustering on recruitment chain to determine the ARR and 95% CIs. We additionally assessed the relationship between IPV and psychological distress and IPV and HIV testing by IPV type (sexual and physical violence). Analyses were also stratified by gender identity to account for gender identity as a potential effect modifier of the association between IPV and no HIV testing and psychological distress and no HIV testing. Stratification by gender identity in the relationship between IPV and psychological distress was conducted in aim 2. A Wald homogeneity test with a conservative significance level of p=0.20, as suggested by Rothman, Greenland, and Lash, was used to determine if these associations were statistically different following stratification by gender identity.[84,85]

We conducted an additional analysis using the 2019 NHBS data, as the 2019 data were more contemporary. However, the 2019 NHBS data measured physical and sexual violence, without specifying that the violence was perpetrated by a partner. All the same analyses were conducted in the 2019 data, but assessing general violence rather than IPV, and the results of this additional analysis are summarized in **Appendix B**.

Results

As in our second aim, 8,078 participated in the NHBS survey in 2016. In 2016, 5,582 (59.8%) had not tested for HIV in the past 12 months. More detailed prevalence measures can be found in **Table 14**. We additionally assessed if HIV testing differed by gender as we did with IPV and psychological distress in the previous aim. HIV testing did not differ by gender with 58.1% of women and 60.6% of men having not tested for HIV in the past 12 months (p=0.6107).

Table 14. Characteristics of the 2016 National HIV Behavioral Surveillance Cycles

Characteristic	N (%) or Median (IQR)
Total	8,078
Any Intimate Partner Violence	1,385 (17.1)
Experienced Physical Violence	1,054 (13.0)
Experienced Sexual Violence	628 (7.8)
Severe Psychological Distress[a]	1,443 (17.9)
No HIV Test	4,788 (59.3)
Gender	
Cisgender man	3,830 (47.4)
Cisgender Woman	4,248 (52.6)
Age (years)	36 (27, 50)
Race/Ethnicity	
White, non-Hispanic	299 (3.7)
Black, non-Hispanic	5,750 (71.2)
Hispanic	1,620 (20.1)
Other	394 (4.9)
Missing	15 (0.2)
Homelessness	
Currently homeless	1,169 (14.5)
Homeless in past 12 months	994 (12.3)
Not homeless in past 12 months	5,914 (73.2)
Missing	1 (0.0)
Education	
<High School	2,374 (29.4)
High School or GED	4,295 (53.2)

>High School	1,409 (17.4)
Marital Status	
Formerly Married/Separated	1,562 (19.3)
Married/Cohabitating	1,357 (16.8)
Never Married	5,159 (63.9)
Missing	0 (0.0)
Sex Partners in the Past Year	
0-1 partners	2,858 (35.4)
2-5 partners	3,741 (46.3)
6-10 partners	859 (10.6)
>10 partners	620 (7.7)
Region	
Northeast	1,886 (23.3)
South	3,519 (43.6)
Midwest	0 (0.0)
West	2,154 (26.7)
Territories	519 (6.4)
Binge Drinking	2,931 (36.3)
Missing	15 (0.2)
Injection Drug Use	455 (5.6)
Non-Injection Drug Use	4,675 (57.9)
Network Size	30 (15, 60)
Missing	3 (0.0)

a: Severe Psychological Distress determined with a score >13 using the Kessler Psychological Distress Scale
IQR: Interquartile range
GED: General Equivalency Diploma

We were unable to determine if psychological distress was a mediator in the relationship between experiencing any IPV and not testing for HIV, as the risk ratio for the natural indirect effect was null (**Table 15**). When separating the types of IPV, we were unable to determine if the relationship between physical or sexual violence and HIV testing was mediated by psychological distress because, once again, the risk ratio for the natural indirect effects were null.

Table 15. Natural Direct and Indirect Effects from Mediation Analysis Assessing Psychological Distress as a Mediator in the Relationship between Intimate Partner Violence and Lack of HIV Testing

	Natural Direct Effect ARR	Natural Indirect Effect ARR (95% CI)
Experienced Intimate Partner Violence	0.98	1.01 (0.94-1.08)
Experienced Physical Violence	0.99	1.01 (0.93-1.09)
Experienced Sexual Violence	1.00	1.01 (0.91-1.11)

all models adjusted for gender, age, housing, education, marital status, binge drinking, non-injection drug use, region, and network size
ARR: Adjusted Risk Ratio
CI: Confidence Interval

As we were unable to determine if psychological distress was a mediator in the relationship between IPV and HIV testing for all types of IPV, we estimated the association for each relationship separately (**Table 16**). Psychological distress trended towards significance in its association with HIV testing as the 95% CI included but does not cross 1 (ARR: 1.04; 95% CI: 1.00-1.09). As discussed in aim 2, any IPV, physical IPV, and sexual IPV were associated with increased psychological distress. Any IPV, physical IPV, and sexual IPV were not associated with HIV testing in the past 12 months.

Table 16. Adjusted Risk Ratios (ARR) and 95% Confidence Intervals (CI) for the Relationships between Intimate Partner Violence and Psychological Distress and HIV Testing

	Any IPV	Physical Violence	Sexual Violence
IPV and no HIV Testing	0.98 (0.94-1.03)	0.99 (0.94-1.04)	1.01 (0.94-1.08)
IPV and Psychological Distress	**1.95 (1.77-2.14)**	**1.89 (1.71-2.09)**	**1.80 (1.65-1.96)**

IPV: intimate partner violence; PD: psychological distress
Significant results in bold

The relationship between IPV and HIV testing significantly differed by gender for all IPV types. However, these relationships were still not statistically significant (**Table 17**). The relationship between psychological distress and HIV testing did not significantly differ by gender (p=0.45) with women having an ARR of 1.02 (0.97-1.08) and men having an ARR of 1.06 (95% CI: 0.97-1.14). Stratification by gender of the relationship between IPV and psychological distress can be found in Aim 2.

Table 17. Adjusted* Risk Ratios (ARR) and 95% Confidence Intervals (CI) for Intimate Partner Violence and No HIV Testing Stratified by Gender

	Men ARR (95% CI)	**Women ARR (95% CI)**	**p-value [a]**
Experienced Intimate Partner Violence	1.02 (0.96-1.07)	0.95 (0.87-1.03)	**0.13**
Experienced Physical Violence	1.03 (0.96-1.10)	0.94 (0.87-1.02)	**0.09**
Experienced Sexual Violence	1.04 (0.98-1.11)	0.96 (0.85-1.08)	**0.17**

*all models adjusted for gender, age, housing, education, marital status, binge drinking, non-injection drug use, region, network size, and injection drug use
a: p-value for Wald Homogeneity test assessing effect modification by gender. A p-value <0.2 was considered significant.
Significant results in bold

Discussion

Among heterosexually active adults at high risk of HIV enrolled in NHBS, we were unable to determine if psychological distress mediated the relationship between IPV and HIV testing. We did, however, find that all types of IPV were associated with severe psychological distress. Neither IPV nor psychological distress was associated with HIV testing.

Among 8,078 participants in our 2016 NHBS sample, over half had not tested for HIV in the past 12 months and HIV testing did not differ by gender. This is lower than the general US population, in which 85.2% have not tested for HIV in the past year. CDC recommends that those at high risk of HIV, such as those in our sample, should be tested at least once every 12 months.[7,97] While it is expected that our study population would be testing at higher rates than the general population, because we are assessing a population of individuals at high risk of HIV infection, this rate is still much lower than recommended. In comparison to NHBS studies among other subgroups at high risk for HIV infection, heterosexually active individuals test for HIV at the lowest rate as compared to MSM and PWID. In the 2014 and 2017 cycles of MSM, 28.9% and 23.4% did not test for HIV in the past 12 months, respectively.[98,99] In the 2015 and 2018 cycles of people who inject drugs, 42.9% and 45.2% did not test for HIV in the past 12 months, respectively.[100,101] These findings demonstrate that more effort should be dedicated to increasing HIV testing in heterosexually active individuals at high-risk of HIV, because their rates of testing are the lowest of the three different subgroups of individuals at high-risk of HIV infection sampled by the CDC through NHBS. Previous studies have assessed strategies for increasing HIV testing among heterosexual populations and found that the major barrier is HIV stigma, the stigma around HIV testing, and a low perceived HIV risk.[12,102,103] One strategy was to include opt-out HIV testing in routine primary care for heterosexually active individuals, but this strategy does not reach individuals that are unable to access primary care.[102] Another study noted that an underutilized opportunity for effectively increasing HIV testing among heterosexual individuals were to provide testing at homeless shelters and jails and/or prisons.[103] A

third qualitative study discussed possible methods of increasing HIV testing among this population would be to increase the number and types of settings offering HIV testing, promoting STI and HIV testing in this population, better integrating STI and HIV testing opportunities, and providing interventions to reduce stigma around HIV testing.[12] Areas deemed to be high priority areas for the EHE plan, should attempt to implement a few of these interventions to increase HIV testing among heterosexually active men and women.

We were unable to determine whether psychological distress mediated the relationship between IPV and HIV testing, because there was no relationship between IPV and HIV testing observed in our data. The natural indirect effects for psychological distress being a mediator in the relationship between IPV and HIV testing were not statistically significant for all types of IPV. This differed from our hypothesis that psychological distress was likely a mediator for the relationship between IPV and HIV testing.

As we were unable to determine that psychological distress was a mediator in the relationship between IPV and HIV testing, we assessed all relationships between IPV, psychological distress, and HIV testing separately. The only relationship that was consistently statistically significant, for all definitions of IPV was the relationship between IPV and psychological distress which was discussed in our second aim.

We found that psychological distress was not associated with HIV testing in this population of heterosexually active adults at high risk for HIV and this relationship did not differ by gender. Our findings were consistent with a previous study among men who are sexual minorities in the US, which found psychological distress was not

associated with HIV testing.[28] Our findings differed from a study conducted among men and women in the deep South, which found HIV testing was more common among men and women who experienced psychological distress.[29] Our conclusion that psychological distress was not associated with HIV testing were counter to what was expected as previous studies have shown that psychological distress is associated with health care avoidance.[58] The deep South study may have been biased, because they did not control for confounders such as age, gender, number of sexual partners, drug use, marital status, and other confounders. In our study, where we controlled for these confounders, we did not find an association between psychological distress and HIV testing. Another previous study found that past psychological distress is more common among those living with diagnosed HIV.[104] If those experiencing psychological distress are at higher risk of HIV as compared to the general population, they should also be tested for HIV at higher rates. A literature review from 2019, established that those with mental health impairments, such as psychological distress, are at higher risk of HIV acquisition, but HIV testing is not being prioritized among this population.[104] One study found that an appropriate area for improvement of HIV testing in this population would be to provide HIV testing in mental health care settings, but once again this misses those who are not participating in regular care.[105] Therefore, a combination of psychological distress screening and HIV testing may be valuable to implement in organizations capable of conducting HIV testing.

IPV was not statistically significantly associated with HIV testing for all IPV types. Our results differed from two studies in women that found HIV testing was more common among those who experienced IPV.[37,38] Our lack of association between IPV

and HIV testing may be due to our inclusion of men in our study, but even in our stratified analysis, this relationship was still not significant among women, so differences may also be due to how these previous studies were over 10 years older, and HIV testing among this population may have changed in that time.

The potential limitations that exist in the second aim, additionally exist in this third aim. This third aim also creates the problem that we conducted a mediation analysis using cross-sectional data in which all variables are measured at the same time point for each individual. We cannot establish that IPV, psychological distress, and HIV testing occurred in the proposed order, but based on previous literature, the hypothesized order as seen in **Figure 7** is logical.[25–29,34–38] Future longitudinal studies should attempt to measure the order in which these occurred in order to determine temporality.

Conclusion

Among the 2016 NHBS sample of heterosexually active adults at high risk for HIV, those experiencing any IPV were more likely to have experienced psychological distress, but those experiencing IPV were not more likely to test for HIV in the past 12 months. Psychological distress was also not significantly associated with HIV testing, and we were unable to declare it a mediator in the relationship between IPV and HIV testing. Additionally, over half of this population of heterosexually active individuals at high risk of HIV, had not been tested for HIV in the past 12 months, even though the CDC recommends that everyone at high risk be tested once a year. Areas with high HIV burdens need to increase HIV testing among heterosexually active individuals through

campaigns to decrease HIV testing stigma, providing HIV testing at homeless shelters and jails/prisons, integrating STI and HIV testing, and providing opt-out HIV testing in routine primary care. More attention also needs to be given to providing connection to psychological care, such as a therapist, psychiatrist, or psychologist, to those experiencing IPV to potentially improve the mental health of heterosexually active individuals at high risk of HIV experiencing IPV. However, providing psychological care in this population is unlikely to affect HIV testing based on our findings that psychological distress did not mediate this relationship.

V. CONCLUSIONS AND FUTURE DIRECTIONS

In this dissertation research, we assessed the methods used to control for selection bias due to respondent driven sampling, quantified the relationship between IPV and psychological distress, and conducted a mediation analysis evaluating the relationship between IPV and HIV testing including psychological distress as a possible mediator among heterosexually active men and women at high risk of HIV infection participating in NHBS in 2016.

This research assessed the experience of IPV among heterosexually active men and women at high risk for HIV infection. The goal was to explore opportunities to improve HIV testing in the US and address psychological distress caused by IPV. The *Ending the HIV Epidemic: A Plan for America (EHE)* has established the importance of increasing testing, particularly among areas with high HIV burdens. As NHBS collected data in areas with high HIV burdens, it is the ideal resource for understanding HIV testing for the purpose of addressing the plan laid out by EHE.

Psychological distress is also an important measure for public health, as diagnosing mental disorders may be beyond the scope of most community-based organizations and health departments. The measure of psychological distress offers a quick 6-question survey that can be easily implemented by an organization with limited resources to either identify individuals with a need to be connected to mental health services or determine a particular population that needs increased availability of mental health services.

In our first aim, based on our simulations comparing RDSAT weighting and GEE for analyzing NHBS data, in all simulations, point estimates were consistently larger for

RDSAT weighting, and GEE consistently provided more precise estimates with lower standard deviations and mean standard errors. However, in an unbalanced dataset, GEE produced incorrectly small standard errors. When increasing the number of clusters from 5 to 100 in an unbalanced sample, GEE, was closest in estimating the variance in the relationship between IPV and psychological distress. We found that when analyzing RDS data, researchers should evaluate the how balanced the recruitment trees are and the number of clusters. Previous studies have defined few clusters as <15.[77] If the recruitment trees are fairly close in size, the recommendations for a balanced tree would be appropriate, and a sample with <15 clusters should utilize the recommendations for a study with few clusters. In a single site sample with few, unbalanced clusters, RDSAT may most correctly estimate the variance, but would generate estimates that are less precise and may produce skewed ARRs due to the larger variance. Another option would be to use a GEE analysis with a correction for variance estimation, in a sample with few clusters.[106,107] However, with a sample with more clusters, the variance estimation issues caused by GEE decreased, and GEE appeared to produce the most precise estimates and be closest in estimating the actual variance of estimates.

In our second aim, we analyzed the relationship between IPV and psychological distress among heterosexually active, cisgender men and women at high risk for HIV infection participating in NHBS in 2016. In this analysis, all types of IPV were associated with psychological distress. The experience of any type of IPV did not differ by gender, unlike what has been seen in previous studies where women experienced IPV at higher proportions as compared to men, highlighting the need to include both men and women

in future studies. However, women were more likely to report severe psychological distress as compared to men. Overall, there was a high prevalence of severe psychological distress in this population (17.9%) as compared to the general population (13.9%). This higher prevalence demonstrates a need to expand psychological distress screening among heterosexually active men and women at increased risk of HIV and connecting those with severe psychological distress to mental health care. Experiencing any IPV, sexual violence, and physical violence were associated with an increased risk of severe psychological distress, and these relationships did not differ by gender. This demonstrates that no matter the type of IPV experienced or the gender of the individual experiencing IPV, they are at increased risk of psychological distress. Although psychological distress screening is needed among all heterosexually active men and women at high risk of HIV, if there are limited resources for improving the mental health of this population, those experiencing physical and/or sexual violence should be prioritized for screening for psychological distress and connected to mental health services. Additionally, organizations addressing intimate partner violence could be a possible point of intervention for improving mental health by introducing a psychological distress questionnaire for all individuals using their services, and could provide referral to mental health care services for those experiencing psychological distress.

In our last aim, among the 2016 NHBS sample, we were unable to determine if psychological distress mediated the relationship between physical violence or any IPV and HIV testing in the past year. Those experiencing sexual violence, physical violence, or any IPV were more likely to experience psychological distress and IPV was not associated with HIV testing. Additionally, over half of this population of individuals at

high risk of HIV had not been tested in the past 12 months, testing did not differ by gender and did not increase between the years of 2016 and 2019. Of all groups surveyed by NHBS, this population of heterosexually active individuals at increased risk of HIV had a higher proportion (59.3%) of participants who had not been tested in the past year. In the 2014 and 2017 cycles of MSM, 28.9% and 23.4% did not test for HIV in the past 12 months, respectively.[98,99] In the 2015 and 2018 cycles of people who inject drugs, 42.9% and 45.2% did not test for HIV in the past 12 months, respectively.[100,101] Areas deemed to be high priority areas for the EHE plan need to increase HIV testing among heterosexually active individuals and previously identified effective methods for doing this include: opt-out HIV testing in routine primary care, testing for HIV at homeless shelters and jails and/or prisons, integrated STI and HIV testing opportunities, and interventions to reduce stigma around HIV testing.[12,102,103] As previously mentioned in our conclusions from our second aim, more attention needs to be given to providing psychological care for those experiencing IPV to benefit their mental health, but this is unlikely to improve HIV testing in this population as psychological distress does not appear to mediate this relationship. However, similar to implementing psychological distress surveys in organizations addressing IPV, these organizations offer another location where HIV testing can be implemented, as previous studies have shown that HIV is more common among individuals experiencing IPV. Although IPV does not appear to be associated with not testing for HIV, HIV testing should still be made accessible among those experiencing IPV.

Also, although data were collected before COVID-19 and associated shelter at home orders, IPV is increasing in the US, and care for individuals experiencing IPV has

become more difficult as individuals experiencing IPV may be sheltering with the perpetrator or may have additional childcare responsibilities.[19–21] The effects of IPV will continue to be seen after this pandemic has ended, demonstrating the need for better understanding how IPV may affect individuals experiencing it. IPV was much more common among this population as compared to the general population, demonstrating that more resources for those experiencing IPV need to be provided in areas that have been deemed as high priority areas in the EHE plan. We also found that IPV was associated with psychological distress, demonstrating the need to improve access to mental health resources at domestic violence shelters. Also, as over half of this population had not tested for HIV, HIV testing needs to increase among heterosexually active individuals at high risk for HIV infection.

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VIII. APPENDIX TABLE OF CONTENTS

Appendix A: Violence and Psychological Distress among Heterosexually Active Individuals Participating in NHBS in 2019

As the 2016 cycle is not the most recent NHBS cycle of heterosexually active individuals, we wanted to conduct our analysis in the most recent heterosexually active cycle, which was 2019. However, the 2019 NHBS cycle did not assess IPV and instead focused on violence, not specifying who perpetrated the violence. In this appendix, we assess the relationship between violence and psychological distress, as was done for the relationship between IPV and psychological distress in our second aim.

The 2019 NHBS sample had all the same inclusion and exclusion criteria as the 2016 cycle discussed in previous chapters, except the 2019 cycle additionally excluded people who inject drugs, as they are captured in a separate cycle of NHBS.[66] The 17 sites in the 2016 sample were: Atlanta, Georgia; Boston, Massachusetts; Dallas, Texas; Denver, Colorado; Los Angeles, California; Memphis, Tennessee; Miami, Florida; Nassau-Suffolk, New York; New Orleans, Louisiana; Newark, New Jersey; Philadelphia, Pennsylvania; Portland, Oregon; San Diego, California; San Francisco, California; San Juan, Puerto Rico; Virginia Beach, Virginia; and Washington, DC.[39] The additional sites included in the 2019 sample were: Baltimore, Maryland; Chicago, Illinois; Detroit, Michigan; Houston, Texas; New York City, New York; and Seattle, Washington. Additionally, the 2019 sample assessed violence, using the same questions without specifying that the violence was by an intimate partner. We conducted all the same analyses as in our second aim using the 2019 data.

The 2019 NHBS efforts surveyed 9,342. The 2019 sample was similar to the 2016 sample except that there were no people who inject drugs, as they were excluded from the 2019 NHBS heterosexual cycle (**Table 18**).

Table 18. Characteristics of the Individuals Participating in the 2019 Heterosexual Cycle of the National HIV Behavioral Surveillance

Characteristic	N (%) or Median (IQR)
Total	9,342
Cisgender man	4,302 (46.1)
Cisgender Woman	5,040 (53.9)
Age	36 (26, 48)
Race/Ethnicity	
White, non-Hispanic	415 (4.4)
Black, non-Hispanic	6,419 (68.7)
Hispanic	2,040 (21.8)
Other	450 (4.8)
Missing	18 (0.2)
Homelessness	
Currently homeless	1,191 (12.7)
Homeless in past 12 months	1,213 (13.0)
Not homeless in past 12 months	6,937 (74.3)
Missing	1 (0.0)
Education	
<High School	2,535 (27.1)
High School or GED	5,183 (55.5)
>High School	1,624 (17.4)
Marital Status	
Formerly Married/Separated	42 (8.0)
Married/Cohabitating	52 (9.9)
Never Married	429 (82.0)
Missing	2 (0.0)
Number of Sex Partners in the Past 12 Months	
0-1 partners	3,665 (39.2)
2-5 partners	4,211 (45.1)
6-10 partners	868 (9.3)
>10 partners	598 (6.4)
Region	

Northeast	2,501 (26.8)
South	3,542 (37.9)
Midwest	836 (8.9)
West	1,996 (21.4)
Territories	467 (5.0)
Binge Drinking	3,371 (36.1)
Missing	25 (0.3)
Non-Injection Drug Use	5,558 (59.5)
Network Size	30 (14, 60)
Missing	1 (0.0)

IQR: Interquartile range
GED: General Equivalency Diploma

Psychological distress prevalence was similar in 2016 (n= 1,443, 17.9%) compared to 2019 (1,581, 16.9%) (**Table 19**). This finding is in contrast to a previous study among the general population of US adults demonstrating an increase in psychological distress from 2018 to 2020.[24] This increase in the previous study among US adults between 2018 and 2020, however, may have been due to the COVID-19 pandemic which would not affect the 2019 NHBS cycle.[24] Before the COVID-19 pandemic, though, psychological distress was much more common among the 2016 and 2019 NHBS populations in comparison to the general US population in 2018 in which 3.9% of US adults experienced psychological distress whereas 17.9% of our 2016 population and 16.9% of our 2019 population experienced psychological distress.[24]

Experience of any violence was reported by 1,912 (20.5%) 2019 NHBS participants. Similar to experience of any IPV in 2016, experience of any violence did not differ by gender (p=0.94). Physical violence was experienced by 1,734 (18.6%) participants and did not differ by gender, as seen in 2016 (p=0.27). Sexual violence was experienced by 440 (4.7%) participants and did differ by gender with sexual violence

being more common among women (6.2%) than men (2.9%) (p<0.01), unlike the 2016 experience of sexual IPV in which there was no difference by gender for all IPV types. This difference in experience and/or reporting of sexual violence by gender demonstrates that perhaps more women experience sexual violence perpetrated by someone who is not an intimate partner as compared to men or there is a difference in reporting general violence that does not occur when reporting intimate partner violence. In the 2010 National Intimate Partner and Sexual Violence Survey, 48.9% of all rape and 64.3% of other sexual violence among women was perpetrated by someone other than an intimate partner.[108] Among men 52.4% of all rape was perpetrated by an acquaintance (intimate partner was not reported), and 64.0% of other sexual violence was perpetrated by someone other than an intimate partner.[108] This other national survey did not find a gender difference in how the respondent knew the person who perpetrated sexual violence towards them. This shows that more research needs to be conducted in the reporting of violence, comparing difference in reporting depending on how the person experiencing the violence knew the perpetrator.

Table 19. Severe Psychological Distress and Experience of Violence by Gender

	Combined (N=9,342)	Woman (N=5,040)	Male (N=4,302)	P-value*
Severe Psychological Distress	1,581 (16.9%)	1,074 (21.3%)	507 (11.8%)	<0.01
Experienced Violence	1,912 (20.5%)	1,030 (20.4%)	882 (20.5%)	0.94
Experienced Physical Violence	1,734 (18.6%)	915 (18.2%)	819 (19.0%)	0.27
Experienced Sexual Violence	440 (4.7%)	314 (6.2%)	126 (2.9%)	<0.01

* p-value determined through clustered chi-square test comparing men and women

Estimates from multivariable regression models suggested that severe psychological distress was associated with all types of violence in the 2019 sample similar to how psychological distress was associated with IPV in the 2016 sample (**Table 20**).

Table 20. Adjusted* Risk Ratios (ARR) and 95% Confidence Intervals (CI) for Types of Violence and Psychological Distress

	ARR (95% CI)
Experienced Any Violence	1.95 (1.77-2.14)
Experienced Physical Violence	1.82 (1.65-2.01)
Experienced Sexual Violence	1.93 (1.73-2.16)

*all models adjusted for gender, age, housing, education, marital status, binge drinking, non-injection drug use, region, and network size

Based on our $p<0.20$ cutoff to determine effect measure modification, the relationship between sexual violence and psychological distress in the 2019 cycle ($p=0.14$) differed by gender. There was a stronger association between sexual violence and psychological distress in woman participants (ARR: 1.98; 95% CI: 1.73-2.27) as compared to men (ARR: 1.53; 95% CI: 1.11-2.10) (**Table 21**). This gender difference in association was not seen in the assessment of IPV in 2016, but there was also not a gender difference in prevalence of the experience of sexual IPV between men and women in 2016, whereas we saw women experience more sexual violence than men in 2019. Gender differences in sexual violence may be due to the actual prevalence, or could be a difference in reporting, as men may be more likely to report experiencing sexual violence in more recent years than they were in previous years.

Table 21. Adjusted* Risk Ratios (ARR) and 95% Confidence Intervals (CI) for Violence and Psychological Distress Stratified by Gender

	Men ARR (95% CI)	Women ARR (95% CI)	p-value [a]
Experienced Any Violence	1.86 (1.59-2.17)	1.97 (1.75-2.23)	0.54
Experienced Physical Violence	1.82 (1.55-2.13)	1.82 (1.59-2.08)	0.93
Experienced Sexual Violence	1.53 (1.11-2.10)	1.98 (1.73-2.27)	0.14

*all models adjusted for gender, age, housing, education, marital status, binge drinking, non-injection drug use, region, and network size
a: p-value for Wald Homogeneity test assessing effect modification by gender. A p-value <0.2 was considered significant.

Our sensitivity analysis, assessing psychological distress as a continuous outcome, rather than the dichotomous variable used in the primary analysis, provided point estimates in the same direction as the primary analysis for the relationship between any violence and psychological distress (**Table 22**). Holding all other variables constant, persons experiencing violence had a mean psychological distress Kessler score that was 1.37 (95% CI: 1.32-1.42) times higher than those not experiencing violence.

Table 22. Adjusted* Point Estimate and 95% Confidence Intervals (CI) for the Relationship between Violence and Psychological Distress Measured as a Dichotomous Variable or as a Score

	Adjusted Point Estimate (95% CI)
Experienced Psychological Distress (Dichotomous)	ARR: 1.95 (1.77-2.14)
Kessler Psychological Distress Score	Ratio of Means: 1.37 (1.32-1.42)

*all models adjusted for gender, age, housing, education, marital status, binge drinking, non-injection drug use, region, and network size

Assessing general violence in 2019 resulted in similar findings as assessing IPV in 2016 in regard to the relationship of either IPV or violence with psychological distress. The primary difference between IPV and general violence analyses was in the experience of sexual violence which did not differ between men and women when perpetrated by an intimate partner, but did differ between men and women when perpetrated by anyone. There was additionally a gender difference in the relationship between general sexual violence and psychological distress that was not seen when assessing the relationship between sexual IPV and psychological distress. This reinforces previous research that shows that sexual violence is more common among women.[69,108] As women are more likely to experience sexual violence and there is a stronger relationship between sexual violence and psychological distress as compared to men, providing psychological distress care for women experiencing general sexual violence needs to be prioritized; but as men experiencing sexual violence were also more likely to experience psychological distress, they should also be provided with screening for psychological distress.

Appendix B: Assessing Psychological Distress as a Mediator in the Relationship between Violence and HIV Testing among Heterosexually Active Individuals Participating in NHBS in 2019

In this appendix, we used the more recent NHBS data to assess if psychological distress mediated the relationship between general violence and HIV testing. We used the same 2019 NHBS sample of heterosexually active individuals at high risk of HIV infection that we used in **Appendix A**. All of the same sites and eligibility criteria were utilized, and there were no additional individuals excluded. HIV testing did not differ by gender (p=0.42). HIV testing did not change between 2016 and 2019, with 4,788 (59.3%) and 5,582 (59.8%), respectively, not testing for HIV in the past 12 months. As HIV testing is not increasing in this population, more attention needs to be given to increasing HIV testing among heterosexually active men and women at high risk of HIV, as based on the CDC recommendations, those at high risk of HIV should be tested for HIV annually.[7] Previous methods to improve HIV testing among this population include opt-out HIV testing in routine primary care for heterosexually active individuals, testing at homeless shelters and jails and/or prisons, integrated STI and HIV testing opportunities, and interventions to reduce stigma around HIV testing.[12,102,103] Areas deemed to be high priority areas for the EHE plan, should attempt to implement a few of these interventions to increase HIV testing among heterosexually active men and women.

As in the assessment of IPV in 2016, we were unable to determine that psychological distress was a mediator between all types of violence and not testing for HIV as the natural indirect effect was not statistically significant (**Table 23**).

Table 23. Natural Direct and Indirect Effects from Mediation Analysis Assessing Psychological Distress as a Mediator in the Relationship between Violence and Lack of HIV Testing

	Natural Direct Effect ARR	Natural Indirect Effect ARR (95% CI)
Experienced Any Violence	0.94	1.01 (0.95-1.07)
Experienced Physical Violence	0.92	1.01 (0.94-1.08)
Experienced Sexual Violence	0.96	1.01 (0.90-1.14)

all models adjusted for gender, age, housing, education, marital status, binge drinking, non-injection drug use, region, and network size
CI: Confidence Interval

As we were unable to determine if psychological distress was a mediator in the relationship between violence and HIV testing for all definitions of violence, we analyzed each relationship separately (**Table 24**). Psychological distress was not associated with HIV testing in 2019 (ARR: 1.04; 95% CI: 1.00-1.08) or 2016 . As discussed in **Appendix B**, any violence, physical violence, and sexual violence were associated with increased psychological distress in 2019, similar to 2016. Unlike the assessment of IPV in our primary analysis, in 2019, any violence (ARR: 0.95; 95% CI: 0.91-0.99) and physical violence (ARR: 0.94; 95% CI: 0.89-0.99) were associated with higher rates of testing for HIV in the past 12 months. Sexual violence was not associated with HIV testing (ARR: 0.98; 95% CI: 0.92-1.05) in the 2019 dataset. So, although IPV was not associated with HIV testing, violence, perpetrated by anyone, was associated with HIV testing. These differences could have been due to changes in HIV testing among those experiencing violence over time, or the difference in how violence was assessed. As the prevalence

of HIV testing did not change over those three years, this relationship between violence and HIV testing is likely due to how violence was assessed.

Table 24. Adjusted Risk Ratios (ARR) and 95% Confidence Intervals (CI) for the Relationships between Violence and Psychological Distress, and HIV Testing

	Any Violence	Physical Violence	Sexual Violence
Violence and no HIV Testing	**0.95 (0.91-0.99)**	**0.94 (0.89-0.98)**	0.98 (0.92-1.05)
Violence and PD	**1.95 (1.77-2.14)**	**1.82 (1.65-2.01)**	**1.93 (1.73-2.16)**

IPV: intimate partner violence; PD: psychological distress
Significant results in bold

The relationship between violence and HIV testing significantly differed by gender for any violence and physical violence, but not for sexual violence. These were the relationships that were significant in the analysis not stratified by gender, but when stratifying, any violence and physical violence were no longer significantly associated with HIV testing among women (**Table 25**). These findings demonstrate that our findings in the overall population were driven by men and that studies may not find an association between violence and HIV testing because they are not including men in the study. IPV and HIV testing differed by gender, but these relationships were not significantly different, showing that in men and women IPV was not associated with HIV testing. Similar to the 2016 NHBS population, the relationship between psychological distress and HIV testing did not significantly differ by gender (p=0.33) with women having an ARR of 1.02 (95% CI: 0.96-1.08) and men having an ARR of 1.06 (95% CI: 1.00-1.12). Stratification of the relationship between IPV and psychological distress can be found in Aim 2.

Table 25. Adjusted* Risk Ratios (ARR) and 95% Confidence Intervals (CI) for Violence and No HIV Testing Stratified by Gender

	Men ARR (95% CI)	Women ARR (95% CI)	p-value [a]
Experienced Violence	**0.90 (0.85-0.96)**	0.98 (0.91-1.04)	**0.07**
Experienced Physical Violence	**0.89 (0.84-0.95)**	0.96 (0.89-1.04)	**0.09**
Experienced Sexual Violence	0.94 (0.82-1.08)	0.98 (0.92-1.05)	0.53

*all models adjusted for gender, age, housing, education, marital status, binge drinking, non-injection drug use, region, and network size
a: p-value for Wald Homogeneity test assessing effect modification by gender. A p-value <0.2 was considered significant.
Significant results in bold

Once again, the findings from our mediation analysis assessing psychological distress as a mediator in the relationship between general violence and HIV testing in the 2019 NHBS was very similar to our findings from our analyses including IPV rather than general violence in the 2016 NHBS. The primary difference was that any violence and physical violence were associated with HIV testing whereas no IPV type was associated with HIV testing. Future studies should assess this relationship between violence and HIV testing, but tease out how violence perpetrated by intimate partners may affect someone differently than violence perpetrated by a stranger.