Heterogeneity in HIV/STI Prevalence, Testing, and PrEP Use among Transgender and Non-binary People and their Partners in the US

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Abstract

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Transgender and non-binary (TNB) people in the U.S. are disproportionately impact by HIV and sexually transmitted infections (STIs). As a result of socio-structural stigma, institutional barriers, and fear of mistreatment, and discrimination, TNB people experience significant barriers to engaging in health care, including HIV/STI prevention. In addition, the HIV/STI prevalence and behaviors of their sex partners may play an important role in TNB people's acquisition of HIV/STIs, and are important for understanding patterns of HIV/STI acquisition and transmission. To improve our understanding of the epidemiology of HIV/STIs, testing, and pre-exposure prophylaxis (PrEP) use among TNB people and their partners, we used three approaches to elucidate heterogeneity within the TNB community based on geography, gender identity and race/ethnicity, and gender of sex partners. First, we applied a Bayesian hierarchical spatial small area estimation model to data from the 2015 US Transgender Survey (USTS), a large national internet-based survey of 26,100 TNB adults, to estimate the county- and state-level proportion of TNB adults who have tested for HIV. Second, we pooled data from five 2017-2021

Washington State HIV/STI surveillance data sources to obtain a large and diverse sample of TNB people as well as cisgender people who reported having a TNB partner in the last year. Using these data we applied descriptive quantitative intersectionality methods to examine differences in HIV/STI testing, PrEP use, healthcare access, and socio-structural factors associated with poverty within TNB communities in Washington state and describe the epidemiology of HIV/STIs and prevention utilization among the partners of TNB people. Third, we developed a novel mathematical model of HIV transmission that more accurately represents the sexual network of TNB people, including trans-trans partnerships, and, for the first time, includes transgender men and non-binary people. We used this model to simulate the potential impact of increasing access to PrEP and more frequent HIV testing among TNB people in the US. We found that there was significant heterogeneity in HIV/STI prevalence and prevention utilization among TNB and their partners across a number of axes of experience, including geography, race/ethnicity, gender identity, sexual minority status, and gender of sex partners. Our findings highlight the need for trans-inclusive models of HIV/STI prevention and PrEP delivery that address multilevel barriers rooted in cissexism and structural racism.

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Introduction

Transgender and non-binary (TNB) people in the U.S. are disproportionately impacted by HIV and sexually transmitted infections (STIs).[1–5] TNB adults and adolescents are estimated to comprise 0.6% of the population, with at least 1.6 million TNB people age 13 and older living in the U.S.[6] HIV prevalence is estimated to be 4.3% to 13.7% among all TNB adults; in addition, 7.1% to 21.5% report having been previously diagnosed with another STI.[5,7] Importantly, there is significant heterogeneity in HIV/STI prevalence among TNB adults, and prevalence is higher within certain racial and gender groups, such a Black transgender women, among whom reported HIV prevalence is as high as 44%.[5]

As a result of socio-structural stigma, institutional barriers, and fear of mistreatment, TNB people experience significant barriers to engaging in health care, including HIV/STI prevention and care.[3,8–10] Due to intersecting marginalization and structural factors such as anti-transgender discrimination and violence, TNB people also disproportionately report syndemic conditions, such as homelessness, substance use, transactional sex, and poverty.[5,11–13] These factors play a role in increasing their vulnerability to acquiring HIV/STIs, and pose additional barriers to accessing care.[14] Consequently, pre-exposure prophylaxis (PrEP) uptake, antiretroviral therapy (ART) coverage, and viral suppression are low in the TNB community relative to cisgender populations at risk for HIV through sexual transmission.[15–20]

Due to a long history of erasure and exclusion from health research,[21–24] there are significant gaps in our understanding of the epidemiology of HIV/STI within TNB communities. Research on the health and wellbeing of TNB communities is significantly limited by the quality and availability of data.[25] Most data on TNB health are from small, cross-sectional, and clinical samples; few national population-based surveys and no HIV surveillance systems collect information on transgender identities using validated measures.[25–28] Additionally, little is known about the sexual and romantic partners of TNB people.[29–31] The HIV/STI prevalence and behaviors of sexual partners may play an important role in TNB people's acquisition of HIV/STI, and are important for understanding patterns of HIV/STI acquisition and transmission.

Therefore, the following questions are critical for improving our understanding of HIV/STIs among TNB populations and for developing targeted, trans-inclusive interventions: How does access to HIV/STI prevention tools vary across U.S. geographies? How does HIV/STI prevalence and prevention utilization vary across racial/ethnic and gender subgroups? Who are the sexual partners of TNB adults? What would be the impact of increasing HIV testing and PrEP coverage among TNB people who are most vulnerable to HIV acquisition?

In Chapter 1, I begin by examining geographic variation in HIV testing among TNB adults. I applied small area estimation methods to a large national dataset in order to obtain county-level estimates of the proportion of TNB adult who tested for HIV within each U.S. counties. In Chapters 2 and 3, I characterize the heterogeneity of HIV/STI prevalence and HIV/STI prevention utilization among TNB people and their sex partners using public health data from Washington State. Lastly, in Chapter 4, I develop a novel national-level mathematical model of HIV transmission among all TNB adults and their partners to predict how increasing HIV testing and PrEP use impacts 10-year HIV incidence for transgender women, transgender men, and non-binary adults.

This research was conducted in collaboration the Seattle Trans and Non-binary Sexual Health (STARS) Advisory Board, a community advisory group of TNB people from the Seattle area. The goal of community advisory boards (CABs) is to address power imbalances in research and incorporate the expertise of community members to produce knowledge in collaboration with academic researchers.[32,33,34] CABs have been used in HIV research for nearly two decades, and are also frequently convened and recommended for ethical research studies of transgender health.[35–41] This research study uses pre-existing data collected from a variety of sources, each of which had varying degrees of scientific leadership by TNB people. CABs can play an important role in addressing power imbalances in secondary data analysis in two key ways. First, when research findings still have the potential to influence clinical encounters and public health decisions that impact trans people and their partners, TNB community members should have a voice in how data are analyzed and interpreted, even if no new data are collected. Second, research findings can be shared with and disseminated more directly to TNB communities from which the data were originally collected. Therefore, it is important to account for the perspectives and priorities of the transgender community in determining which parts of the quantitative results should be highlighted in scientific dissemination, as well as the language and discourses used to discuss the findings.[36]

The STARS Advisory Board met bimonthly between February 2021 and July 2022 (for a total of 10 meetings) and was informed by principles of community-based participatory research. The advisory board included 9 TNB people from the Seattle area who were diverse with respect to their gender identity (trans women, trans men, non-binary and genderqueer individuals), race/ethnicity (Black, Pacific Islander, Latinx, and White), and professional experiences (nursing, social work, LGBTQ advocacy, law, public health practice, and drag performance art). The STARS Advisory Board provided feedback to refine research questions, guide data analytic choices, and inform the interpretation and reporting of the key findings. Members were compensated for their participating in advisory board meetings ($75 cash transfer per meeting attended), were invited to critically review manuscripts, coauthor related publications, and co-present research findings.

This body of research can be used to inform clinical care and targeted public health interventions for gender minorities and their partners. The development of county-level estimates of HIV testing across the U.S. will support the understanding of local and regional disparities in HIV testing among TNB populations. Statistical modeling, including small area estimation, may be especially important for TNB populations due to the sparsity of national data. Similarly, mathematical models are powerful tools for predicting the impact of targeted interventions on HIV incidence, and are important in the absence of longitudinal data on interventions for TNB populations.[42] However, these models require information on HIV-related behaviors and patterns of sexual partnering, which will be generated in Chapters 2 and 3. Few epidemic models include TNB individuals, and Chapter 4 will be the first HIV model to include transgender men and non-binary individuals.

Chapter 1: Geographic Variation in HIV Testing among Transgender and Non-binary Adults in the United States

ABSTRACT

Background: Transgender and non-binary (TNB) populations are disproportionately impacted by HIV and few local health departments or HIV surveillance systems collect/report data on TNB identities. Our objective was to estimate the prevalence of HIV testing among TNB adults by US county and state, with a focus on the Ending the HIV Epidemic (EHE) geographies.

Methods: We applied a Bayesian hierarchical spatial small area estimation model to data from the 2015 US Transgender Survey (USTS), a large national cross-sectional internet-based survey. We estimated the county- and state-level proportion of TNB adults who ever tested or tested for HIV in the last year by gender identity, race/ethnicity, and age.

Results: Our analysis included 26,100 TNB participants with valid zip codes who resided in 1,688 counties (54% of all 3,141 counties that cover 92% of the US population). The median county-level proportion of TNB adults who ever tested for HIV was 44% (range 10-80%) and who tested in the last year was 17% (range 4-44%). Within most counties, testing was highest among transgender women, Black respondents, and people age ≥25. HIV testing was lowest among non-binary people and young adults age <25. The proportion of TNB adults who tested within the last year was very low in most EHE counties and in all 7 rural states.

Conclusions: HIV testing among TNB adults is likely below national recommendations in the majority of EHE geographies. Geographic variation in HIV testing patterns among TNB adults indicates that testing strategies need to be tailored to local settings.

INTRODUCTION

HIV testing has long been an important component of HIV prevention. Knowledge of HIV status is important to reduce HIV-associated health outcomes through early diagnosis and linkage to care, as well as for prevention. Since 2006, the United States (US) Centers for Disease Control (CDC) has recommended universal screening for HIV at least once in a person's lifetime and annually for persons at increased risk of acquiring HIV[43,44]. In 2019, the US Department of Health and Human Services (HHS) unveiled the *Ending the HIV Epidemic* (EHE) initiative, a federal strategy to reduce the number of new HIV diagnoses by 90% by 2030[45]. One of the four pillars of this initiative includes "diagnosing all individuals with HIV as early as possible" after HIV acquisition.

In the US, transgender and non-binary (TNB) people are disproportionally burdened by new HIV diagnoses.[5,45] In addition, approximately one third to half of TNB adults report behaviors[5,46,47] that meet CDC recommendations for annual HIV testing, which includes anyone who: had anal or vaginal sex with an HIV positive partner; more than one sex partner since last HIV test; shared injection equipment; exchanged sex for drugs or money; diagnosed with another sexually transmitted infection (STI), hepatitis or tuberculosis; or had sex with a man who has sex with men (MSM) or someone who is fits the above criteria[48]. As a result of socio-structural barriers to engaging in health care, including HIV prevention and care,[3,8–10] pre-exposure prophylaxis (PrEP) uptake, antiretroviral therapy (ART) coverage, and viral suppression are low in the TNB community relative to cisgender populations[15–20]. However, available data on HIV testing among TNB adults are mixed. A recent meta-analysis estimates that 75% of transgender women and 69% of transgender men have ever been tested for HIV[5]. A small national probability sample similarly found that 77% of sexually active TNB adults had ever tested for HIV[46]. In contrast, data from the

Behavioral Risk Factor and Surveillance System (BRFSS) found that only 37% of TNB adults have ever been tested for HIV[20].

To achieve the EHE initiative's ambitious target, the Department of HHS identified 50 local areas and 7 rural states in which over 50% of the new HIV diagnoses occurred between 2016-2017 to be prioritized for additional resources that would support HIV prevention initiatives[49]. The EHE initiative necessitates the availability of reliable state- and county-level data on HIV testing, PrEP uptake, and other HIV prevention efforts in order to effectively target resources. However, few local or state health departments report information on TNB identities, and most HIV surveillance systems inconsistently measure TNB identities[50]. In addition, few national surveys or HIV/STI surveillance systems use validated trans-inclusive measures for ascertaining gender (e.g. the two-step method)[27,50–52]. Therefore, although frequent HIV testing is a crucial tool for HIV prevention, there are few local data sources on HIV testing among TNB people.

The objective of this study was to estimate the proportion of TNB adults who have ever or recently tested for HIV, with a focus on the EHE geographies. To do this, we obtained county- and state-level estimates with the goal of addressing the need for local and regional data on HIV testing among TNB populations.

METHODS

Data source

The 2015 US Transgender Survey (USTS), conducted by the National Center for Transgender Equality (NCTE), is the largest and most comprehensive survey to date on the experiences of transgender people living in the US[3]. The USTS was an anonymous, online national survey that included 27,715 individuals age 18 and older who identified as transgender and lived in the 50 states, US territories, and military bases overseas at the time of the survey. The NCTE conducted outreach though transgender and LGBTQ+ organizations, and included social media campaigns, survey taking events, and an Advisory Committee comprised of transgender individuals to increase community engagement and shared the survey through their professional networks. The USTS was administered through an online instrument available in English and Spanish. Data were collected over a 34-day period in 2015. The present secondary analysis of these data including zip codes received ethical approval by the University of Washington Institutional Review Board.

Measures

The survey included 324 questions across a broad range of topics, including health, discrimination, employment, education, housing, and demographics. Questions related to HIV testing included: "*Have you ever been tested for HIV?" and "What month/year did you receive your last HIV test?"* Nearly all participants (99.9%) responded to HIV testing questions. We used responses to these questions to create two analytic binary variables: (i) ever tested for HIV, and (ii) tested for HIV in the last year.

Our analysis included county-level measures of factors that we determined *a priori* to be associated with structural and individual-level barriers and facilitators of HIV testing: the proportion of survey respondents who were Black, Hispanic/Latinx, age <25 years old, completed a high school education or less, unemployed, and experienced discrimination or mistreatment (e.g. denied service, harassed, attacked) in a place of public accommodation (e.g. retail stores, hotels, public transportation and government offices) in the past year. We also used the standard survey weights developed by the USTS to adjust for race, ethnicity, and age.

Geographic units of analysis

The primary geographic units of analysis were US counties or county equivalents. Valid zip codes were available for nearly all (96.8%) respondents. Our analysis excluded individuals without a valid zip code (Appendix A). Zip codes were attributed to a county using the Department of Housing and Urban Development's 2015 geographies crosswalk. When a zip code was split across more than one county, we allocated the zip codes to the county with the majority of residences. Each county was categorized as metropolitan, non-metropolitan urban, or rural based on the urban-rural continuum codes by the US Department of Agriculture[53]. We also conducted state-level analyses for the 7 rural states identified by the EHE initiative.

Statistical analysis

We conducted area-level small area estimation modeling to estimate the proportion of TNB adults who tested for HIV within each county for all counties for which the USTS had data. Direct estimators in areas with small sample size have large sampling variability and unstable estimates. To overcome this problem, we used a Bayesian hierarchical model that includes both random effects at the area-level and spatial random effects. We used a framework adapted from prior work by Chen, Mercer, Wakefield, and Song[54–57]. Our model includes a fixed overall level or "intercept", county-level random effects, spatial effects, and area-level covariates. Spatial effects were modeled using an Intrinsic Conditional Auto-Regressive (ICAR) model for spatial smoothing. ICAR models are a class of spatial models that smooth "noisy" area-level estimates by pooling information from neighboring counties[55,56]. Technical details are provided in Appendix A.

We used complete-cases analysis due to minimal missingness among our variables of interest. For each county and state, we report modeled estimates of the mean and 95% credible intervals of the posterior distribution of the proportion of all TNB adults who have ever tested for HIV and who tested for HIV in the last year. We conducted subgroup analyses by gender identity (transgender women, transgender men, non-binary), race/ethnicity (Asian or Native Hawaiian/Pacific Islander (NHPI), Black, Hispanic/Latinx, Native American/Alaska Native, White), and age (<25 and ≥25 years old). People who reported multiple races could be categorized in multiple groups. Due to the small number of respondents who reported a NHPI race, we aggregated this group with Asian participants. We do not report count data, point estimates, and credible intervals for geographic areas with fewer than 20 survey respondents. However, these estimates are included in figures (e.g. maps, density plots) and aggregate statistics (e.g. medians, ranges). All analyses were conducted in R statistical software version 3.6.2, and modeling was conducted using the SUMMER package.[58,59] Scripts are available at https://github.com/dianatordoff/ustssae.

RESULTS

Our sample included 26,100 participants who had a valid zip code. Participants resided in 1,688 counties (54% of all 3,141 US counties that cover 92% of the US population). The number of participants per county ranged from 1 to 783, although the majority of counties (n=1,411, 84%) included <20 participants (see Appendix A). Overall, 34% of the participants were transgender women, 30% were transgender men, and 36% were non-binary (7% assigned male at birth and 29% assigned female at birth).

There was significant geographic variation in estimates of HIV testing. The median county-level proportion of TNB people who ever tested for HIV was 44.1% (range 9.7-80.2%; Figure 1.1A) and who tested for HIV in the last year was 17.2% (4.2-44.1%; Figure 1.1B). Detailed state- and county-level maps and estimates are available online at http://links.lww.com/QAI/B795.

Among EHE priority geographies, Kings County, New York (80.2% ever tested; 44.1% tested in the last year), Washington, D.C. (74.3% ever tested; 42.9% tested in the last year), and

San Francisco County, California (77.5% ever tested; 37.9% tested in the last year) were among the top five counties for both ever and recent HIV testing (Table 1.1). Alabama and Mecklenburg County, North Carolina had the lowest proportion of TNB adults who had ever tested for HIV (41.7% and 41.5%, respectively) and Riverside County, California had the lowest proportion of TNB adults who had tested for HIV in the last year (14.9%). Notably, the estimated proportion of TNB adults who had been recently tested was very low—below 25%—in 28 of the 50 priority counties (located in Arizona, California, Florida, Georgia, Ohio, Nevada, and Texas) and in all 7 rural states.

We observed differences in ever HIV testing by gender identity, race/ethnicity, and age (Table 1.2). Generally, these differences were attenuated when we examined the proportion of people who had tested within the last year, compared to ever testing (Figure 1.2). Among EHE priority geographies, HIV testing was usually highest among transgender women and lowest among non-binary adults (median estimated difference of 18.3 percentage points). HIV testing among transgender men was similar to transgender women in some counties (e.g. Cook County, Illinois and King County, Washington), and was between HIV testing estimates for transgender women and non-binary adults in other counties (e.g. Orange County, California and Tarrant County, Texas). Within most EHE counties, HIV testing was highest among Black participants. HIV testing among Asian/NHPI respondents varied significantly between geographies: this proportion was the lowest in some counties (e.g. Washington, D.C. and Gwinnett County, Georgia) and the highest in others (e.g. Pinellas County, Florida and Tarrant County, Texas). Hispanic/Latinx and White participants showed similar variations in HIV testing across counties. Last, we observed that TNB adults age ≥25 were significantly more likely to have ever tested for HIV or have been tested in the last year compared to young adults age <25 within nearly all counties (median estimated difference of 37.8 percentage points). We did not observe major differences in the county-level proportion of TNB adults who tested for HIV by region of the US or by urban/rural designation (Appendix A).

DISCUSSION

We estimated the county-level proportion of transgender adults who ever or recently tested for HIV by applying spatial small area estimation methods to the largest national survey of TNB adults conducted in the US to date. We observed significant county-level variation in the estimated proportion of TNB adults who had ever tested for HIV (9-80%) or tested for HIV in the last year (4-44%). HIV testing was very low in many counties and in all 7 rural states prioritized by the EHE initiative. Subgroup analysis revealed that some patterns of HIV testing were consistent across geographies (e.g. a lower proportion of young adults tested for HIV), while patterns of HIV testing by gender identity and race/ethnicity varied among counties. In many of the EHE geographies, transgender women and Black participants were most likely to have tested for HIV, although this was not always the case. This further highlights the need for localized data for understanding disparities in HIV testing rates among subpopulations of TNB adults.

The HIV testing patterns observed in our study may reflect disparities in HIV prevalence among TNB people by gender, race, and ethnicity, which is highest among transgender women of color. In 2019, the National HIV Surveillance System observed an HIV prevalence of 62% among Black, 65% among Native American, and 35% among Latina transgender women living in 7 US cities.[60] In contrast, HIV prevalence among transgender men is estimated to be 2%.[5,61] Differences in HIV testing may reflect differences in perceived HIV risk as well as HIV testing and prevention efforts that have specifically sought to engage Black TNB people given that they are disproportionately impacted by HIV[5]. For example, two studies on PrEP uptake found that the majority of HIV-negative TNB adults (55-90%) have low self-perceived HIV risk.[47,62] In contrast, another study among transgender MSM found congruency between high perceived HIV risk and PrEP indications.[63] Lastly, it is notable that a very low proportion of young adults <25 have ever or recently tested for HIV since they account for 35% of all new HIV diagnoses among TNB people.[64]

Prior studies have not consistently reported differences in testing among transgender women and men; moreover, no studies have previously reported on HIV testing among non-binary adults[5,20,65]. However, several studies have documented racial differences in HIV testing among TNB adults, similar to those observed in our analysis. Data from the BRFSS found that ever HIV testing is significantly higher among Black transgender women and men (63% and 67%) compared to White transgender women and men (33% and 31%)[20]. Another study of transgender women conducted across 23 US cities found that Black and Hispanic/Latinx transgender women were more likely to test for HIV relative to White transgender women[66]. A third study found that TNB people of color were 8-times more likely to meet CDC's recommendations for annual HIV testing (OR 8.2; 95% CI 2.3-28.8)[46].

To date, only two national probability samples have collected data on HIV testing among TNB adults—the BRFSS and the TRANSPOP study, a two-phase probability sample and telephone survey based on Gallup's random digit dialing. However, neither of these surveys have sufficient sample size or geographic scope to provide state- or county-level estimates of HIV testing among transgender populations. Overall, our estimate of ever HIV testing among TNB adults are higher than what was observed in the BRFSS (37%) and lower what was observed in the TRANSPOP study (77%)[20,46]. Comparing our results to estimates from the BRFSS is challenging. As demonstrated in our supplementary analyses (see Appendix A), state-level estimates of HIV testing using BRFSS data in transgender adults are, on average, 17 percentage-points lower than estimates using USTS data. Although the BRFSS is a probability sample, it is a telephone-based survey, does not assess transgender status using the validated/recommended two-step question, uses outdated terminology, and excludes homeless and institutionalized populations[51]. Thus, inconsistencies between these two data sources is likely an artifact of differing target populations, methodologies, sampling and response bias between the two surveys.

The proportion tested that is reported in the TRANSPOP study is similar to estimates from a recent meta-analysis of clinical and convenience samples by Becasen et al., which reported that 73% of transgender women and men had ever tested for HIV[5]. We found that only 12 EHE geographies have 95% credible intervals that fall within this range estimated by the TRANSPOP study or Becasen et al. (i.e. 73-77%). These 12 geographies are all large metropolitan counties in or around the following cities: the greater New York area (New York, Kings, Queens, Bronx, and Hudson counties); the San Francisco Bay Area (San Francisco and Alameda counties); Washington, D.C. and the neighboring Montgomery County, Maryland; Suffolk County, Massachusetts; Philadelphia County, Pennsylvania; and Orleans Parish, Louisiana. Thus, HIV testing among TNB adults among the remaining 37 counties and 7 rural states is significantly lower than what has been reported in these two studies. This may be due to differences in sampling and reporting. For instance, the TRANSPOP study restricted their analysis to 45% of their sample who were sexually active with cisgender men or transgender women. In addition, meta-analysis estimates are likely vulnerable to selection bias and over representation of transgender adults living in the above geographies. The authors reported that the majority (52%) of studies included in the meta-analysis were located in San Francisco, New York, Los Angeles, or Boston.

Our results suggest that a similar proportion of TNB people have been tested for HIV compared to the US general adult population, but that this proportion is lower than what has been observed in other populations vulnerable to HIV acquisition. Two recent studies used data from the BRFSS to estimate the overall proportion of adults who have been tested for HIV in EHE geographies using data from 2016-2017 as well as to estimate national temporal trends in HIV testing by race, age, and binary male/female categories[67–69]. The first of these studies found significant geographic variation in the proportion of all adults who had ever tested for HIV (30% to 71%) and who tested for HIV in the last year (7% to 26%)[67]. Similar to our study, the authors concluded that HIV testing was suboptimal in most EHE geographies, and was lowest in jurisdictions with low HIV diagnosis rates. The second of these two studies also found that proportion of all adults who had ever been tested for HIV was highest among Black respondents (69%), followed by Hispanic/Latinx (48%) and White respondents (42%) and that young adults age <25 were significantly less likely to have ever tested for HIV (32%)[68]. They also found that BRFSS respondents who self-reported any behaviors associated with increased risk of HIV acquisition were more likely to have ever tested (65% v. 44%) or tested for HIV in the last year (34% v. 13%) compared to respondents who did not report these behaviors (which included injection drug use, transactional sex, condomless anal sex, STI diagnosis, or ≥4 partners in the past year).

In addition, a recent large online sample of transgender and cisgender MSM found that although transgender men reported high rates of ever HIV testing or testing in the last year (71% and 61%, respectively), transgender men tested less frequently than cisgender men in the same sample[70]. These findings are consistent with a systematic review of HIV testing among MSM that estimated 63-91% of MSM had ever tested for HIV while 39-67% has been tested in the last year[44].

Lastly, Antebi-Gruszka et al. also found that transgender MSM who lived in the South were significantly less likely to have tested for HIV compared to those who lived in the Northeast, Midwest or West[70].

This analysis had several limitations. The 2015 USTS used non-probability sampling and is vulnerable to sampling bias. Although the USTS is the largest and most comprehensive sample of TNB adults, there remained significant gaps in geographic coverage, particularly in rural regions of the Midwest and Southern US. In addition, we were only able to obtain small area estimates for the contiguous US, and thus excluded Alaska, Hawaii, Puerto Rico, and Guam. This analysis also relied on self-reported HIV testing behaviors, which are vulnerable to recall and social desirability bias. Measures of recent HIV testing are more likely to be inflated as a result of these biases than measures of ever HIV testing. These data were collected in 2015 and may not be reflective of current HIV testing, although national data suggest that trends in HIV testing have not significantly changed between 2011-2017[68]. Lastly, the USTS does not ask questions about the gender of sex partners or other sexual behaviors, which means we were unable estimate rates of HIV testing among sexually active TNB participants.

Despite these limitations, these county-level data may be invaluable to local health departments who likely lack data on HIV testing in their local TNB community, and should be used to motivate HIV testing efforts that are inclusive and responsive to the needs of the TNB community. Trans-inclusive HIV prevention strategies must address stigma and structural barriers to accessing care, provide gender-affirming services, and center the strengths and priorities of local TNB communities.[42,71,72] Notably, peer support within trans communities improves engagement in HIV prevention, and these social networks can be leveraged to disseminate HIV innovations and reach individuals who are not currently engaged in HIV prevention services. In addition, trans-inclusive data collection and reporting are critical for monitoring the success and reach of these strategies.[73]

"Diagnosing all individuals with HIV as early as possible" after HIV acquisition is one of the four pillars of the EHE initiative and HIV testing is a critical access point for a range of HIV prevention and treatment interventions (e.g. PrEP and treatment as prevention). To our knowledge, this study is the first to provide state- and county-level estimates of HIV testing for TNB adults, filling a gap in jurisdiction-level data on TNB populations. We found that geographic variation in HIV testing among TNB adults mirrors patterns observed for all adults living in the US, and that ever and recent HIV testing is below recommended levels in most states and counties. In addition, differences in HIV testing by gender identity and race/ethnicity varied across geographies, suggesting the HIV testing strategies may need to be tailored to meet local needs. Overall, these findings highlight the importance of trans-inclusive HIV testing and prevention strategies within the EHE geographies, to achieve a 90% reduction in new diagnoses by 2030.

TABLES & FIGURES

Table 1.1. Estimated Proportion of Transgender and Non-binary Adults who have Tested for HIV among Geographies Prioritized by the Ending the HIV Epidemic Initiative, 2015 US Transgender Survey

State	County	N	Ever tested for HIV % (95% CI)	Tested for HIV in the last year % (95% CI)
49 County Equivalents				
Arizona	Maricopa	295	47.8 (42.5, 53.1)	19.7 (15.7, 24.0)
California	Alameda	439	75.0 (71.2, 78.7)	32.7 (28.6, 37.0)
California	Los Angeles	701	59.2 (55.7, 62.7)	27.8 (24.6, 31.1)
California	Orange	172	47.2 (40.6, 53.8)	17.4 (12.8, 22.5)
California	Riverside	106	42.1 (34.4, 50.0)	14.9 (10.1, 20.5)
California	Sacramento	169	62.8 (56.4, 69.0)	23.0 (17.7, 28.7)
California	San Bernardino	91	47.0 (38.9, 55.3)	20.4 (14.4, 27.2)
California	San Diego	269	63.6 (58.3, 68.9)	25.6 (21.0, 30.5)
California	San Francisco	255	77.5 (72.6, 82.1)	37.9 (32.4, 43.5)
District of Columbia	Washington	206	74.3 (68.9, 79.3)	42.9 (36.8, 49.2)
Florida	Broward	71	60.6 (51.3, 69.6)	27.2 (19.5, 35.8)
Florida	Duval	52	48.0 (37.7, 58.3)	22.2 (14.9, 30.8)
Florida	Hillsborough	89	43.2 (34.9, 51.6)	17.8 (12.3, 24.4)
Florida	Miami-Dade	62	52.1 (42.1, 62.1)	22.4 (15.2, 30.7)
Florida	Orange	104	44.7 (36.9, 52.6)	17.2 (11.9, 23.2)
Florida	Palm Beach	47	48.2 (37.4, 59.2)	18.7 (11.9, 27.0)
Florida	Pinellas	84	55.2 (46.4, 63.9)	17.1 (11.5, 23.6)
Georgia	Cobb	58	44.7 (35.5, 54.0)	17.9 (11.8, 25.3)
Georgia	De Kalb	125	61.5 (54.2, 68.5)	30.3 (23.7, 37.5)
Georgia	Fulton	81	59.8 (51.4, 67.9)	26.7 (19.5, 34.7)
Georgia	Gwinnett	46	57.0 (47.0, 66.6)	23.2 (15.4, 32.2)
Illinois	Cook	533	63.9 (60.0, 67.7)	33.5 (29.7, 37.4)
Indiana	Marion	94	53.8 (45.7, 61.9)	24.4 (17.9, 31.8)
Louisiana	East Baton Rouge	53	50.2 (40.1, 60.3)	22.0 (14.7, 30.6)
Louisiana	Orleans	70	72.9 (64.5, 80.6)	30.0 (21.9, 38.7)
Maryland	Baltimore	85	56.7 (48.4, 64.8)	22.9 (16.3, 30.2)
Maryland	Montgomery	137	67.2 (60.4, 73.6)	31.6 (25.0, 38.5)
Maryland	Prince Georges	84	61.6 (53.3, 69.4)	29.5 (22.0, 37.7)
Massachusetts	Suffolk	204	69.1 (63.3, 74.5)	38.2 (32.2, 44.4)
Michigan	Wayne	98	45.0 (37.1, 53.1)	20.4 (14.5, 27.1)
Nevada	Clark	107	50.8 (42.9, 58.7)	19.8 (14.1, 26.2)

New Jersey	Essex	34	60.8 (50.4, 70.6)	27.7 (18.6, 38.0)
New Jersey	Hudson	33	64.0 (53.7, 73.6)	25.9 (17.2, 36.0)
New York	Bronx	49	67.5 (58.2, 76.1)	30.9 (22.0, 40.8)
New York	Kings	365	80.2 (76.2, 83.9)	44.1 (39.3, 49.1)
New York	New York	216	65.6 (59.7, 71.3)	34.9 (29.1, 40.8)
New York	Queens	116	65.3 (57.9, 72.5)	38.3 (30.8, 46.2)
North Carolina	Mecklenburg	67	41.5 (32.6, 50.5)	20.8 (14.2, 28.4)
Ohio	Cuyahoga	118	51.6 (44.1, 59.1)	23.1 (17.2, 29.7)
Ohio	Franklin	173	44.6 (38.2, 51.1)	17.6 (13.0, 22.6)
Ohio	Hamilton	82	46.3 (37.8, 54.8)	18.8 (12.9, 25.7)
Pennsylvania	Philadelphia	280	71.7 (66.8, 76.4)	36.2 (31.0, 41.5)
Tennessee	Shelby	34	61.4 (50.4, 71.7)	27.1 (18.1, 37.4)
Texas	Bexar	94	43.9 (35.7, 52.3)	20.2 (14.2, 27.2)
Texas	Dallas	152	50.1 (43.2, 57.0)	21.9 (16.5, 27.8)
Texas	Harris	219	57.2 (51.2, 63.1)	27.9 (22.6, 33.5)
Texas	Tarrant	108	42.6 (35.0, 50.4)	19.4 (13.8, 25.8)
Texas	Travis	242	57.8 (52.0, 63.4)	20.2 (15.8, 24.9)
Washington	King	783	62.4 (59.1, 65.6)	28.3 (25.3, 31.5)
7 Rural States				
Alabama		212	41.7 (36.8, 46.5)	16.2 (13.0, 19.8)
Arkansas		214	43.0 (38.6, 47.5)	15.9 (13.0, 19.2)
Kentucky		254	47.1 (42.9, 51.3)	19.6 (16.3, 23.0)
Mississippi		80	49.0 (43.1, 55.0)	20.9 (16.4, 26.0)
Missouri		479	46.2 (42.7, 49.6)	18.0 (15.4, 20.7)
Oklahoma		203	44.6 (40.0, 49.5)	17.1 (13.8, 21.0)
South Carolina		220	42.3 (37.2, 47.5)	19.8 (15.9, 24.0)

Table 1.2. County-level Variation in the Estimated Proportion of Transgender and Non-binary Adults who have Tested for HIV among all US counties, by Gender Identity, Race/Ethnicity, and Age Subgroups, 2015 US Transgender Survey

Demographic Subgroups	N[a]	Ever tested for HIV % median (range)[b]	Tested for HIV in the last year % median (range)[b]
Overall	26,100	44.1 (9.7, 80.2)	17.2 (4.2, 44.1)
Gender Identity			
Transgender women	8,987	57.3 (22.3, 84.6)	19.5 (9.0, 55.7)
Transgender men	7,679	45.9 (7.6, 80.1)	18.0 (5.1, 45.5)
Non-binary	9,434	32.5 (8.1, 85.1)	13.4 (3.8, 43.7)
Race/Ethnicity[c]			
Asian/NHPI	1,122	46.3 (17.0, 86.0)	21.4 (9.0, 56.9)
Black	1,231	66.7 (29.0, 87.2)	32.6 (20.0, 47.5)
Hispanic/Latinx	1,940	48.0 (14.2, 81.5)	22.3 (7.0, 57.7)
Native American/Alaska Native	708	70.9 (24.4, 82.9)	28.6 (17.5, 41.1)
White	21,452	44.8 (10.0, 80.1)	16.6 (3.9, 44.3)
Age			
18-24 years old	11,276	24.8 (10.4, 58.5)	13.5 (5.1, 37.2)
≥25 years old	14,824	61.5 (39.8, 87.9)	19.2 (12.7, 48.1)

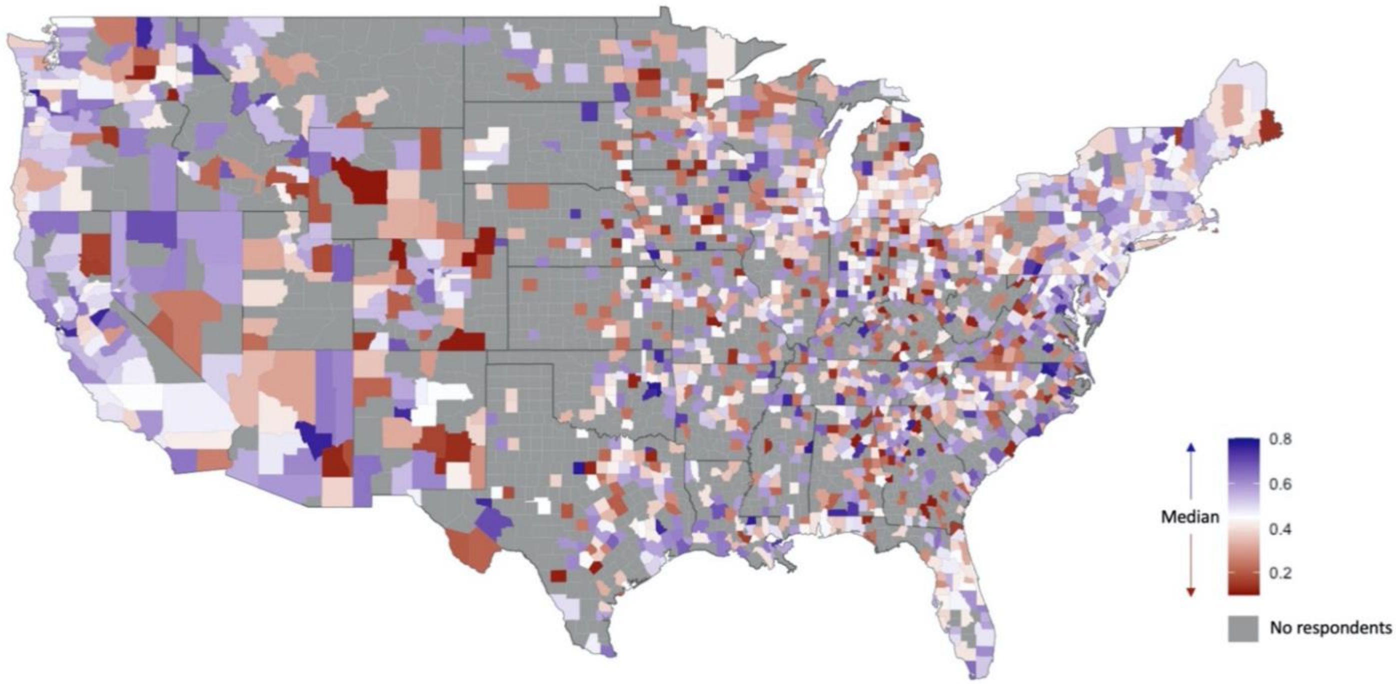
[a] *Total number of participants with a valid zip code.*

[b] *Median and range across all US counties of the mean of the posterior distribution of the estimated proportion of participants who tested for HIV.*

[c] *Participants who reported multiple races could be categorized in multiple groups; 75 participants did not provide a race/ethnicity.*

Figure 1.1. County-level Map of the Proportion of Transgender and Non-binary Adults who have Tested for HIV, 2015 US Transgender Survey

A. Ever tested for HIV



B. Tested for HIV in the last year

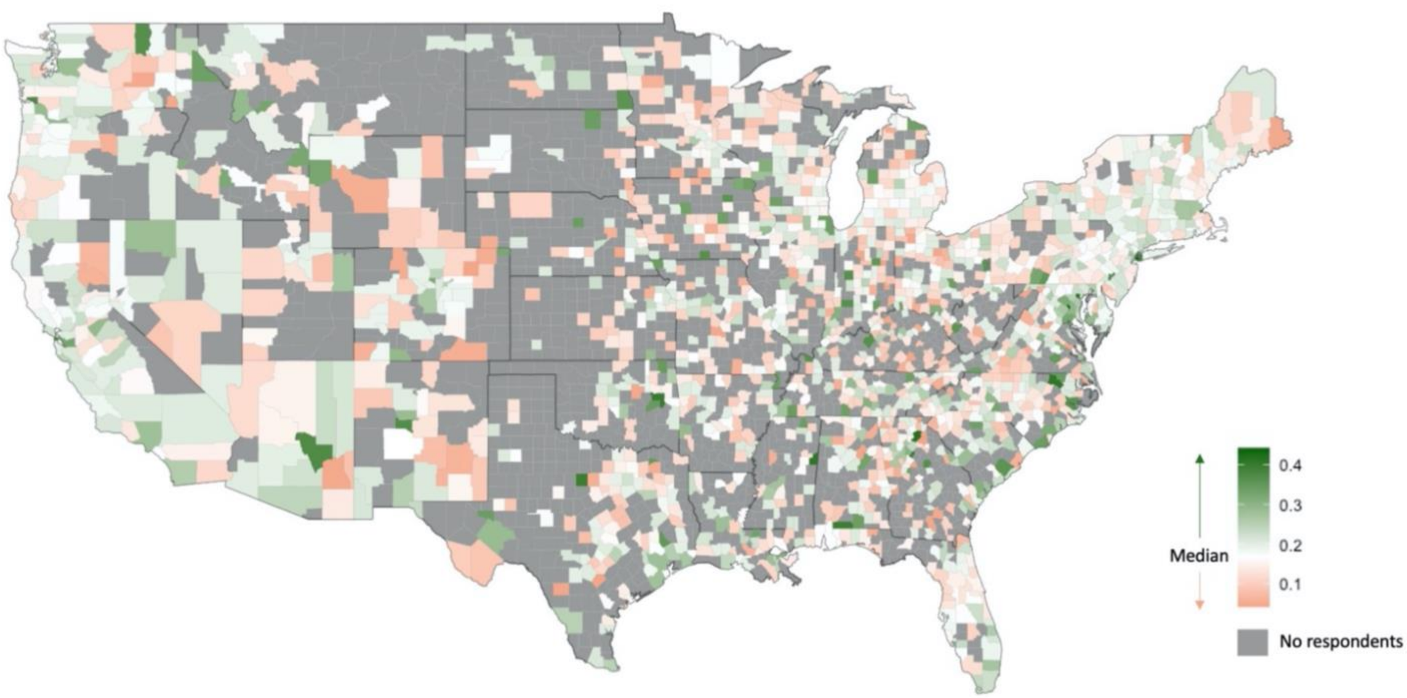
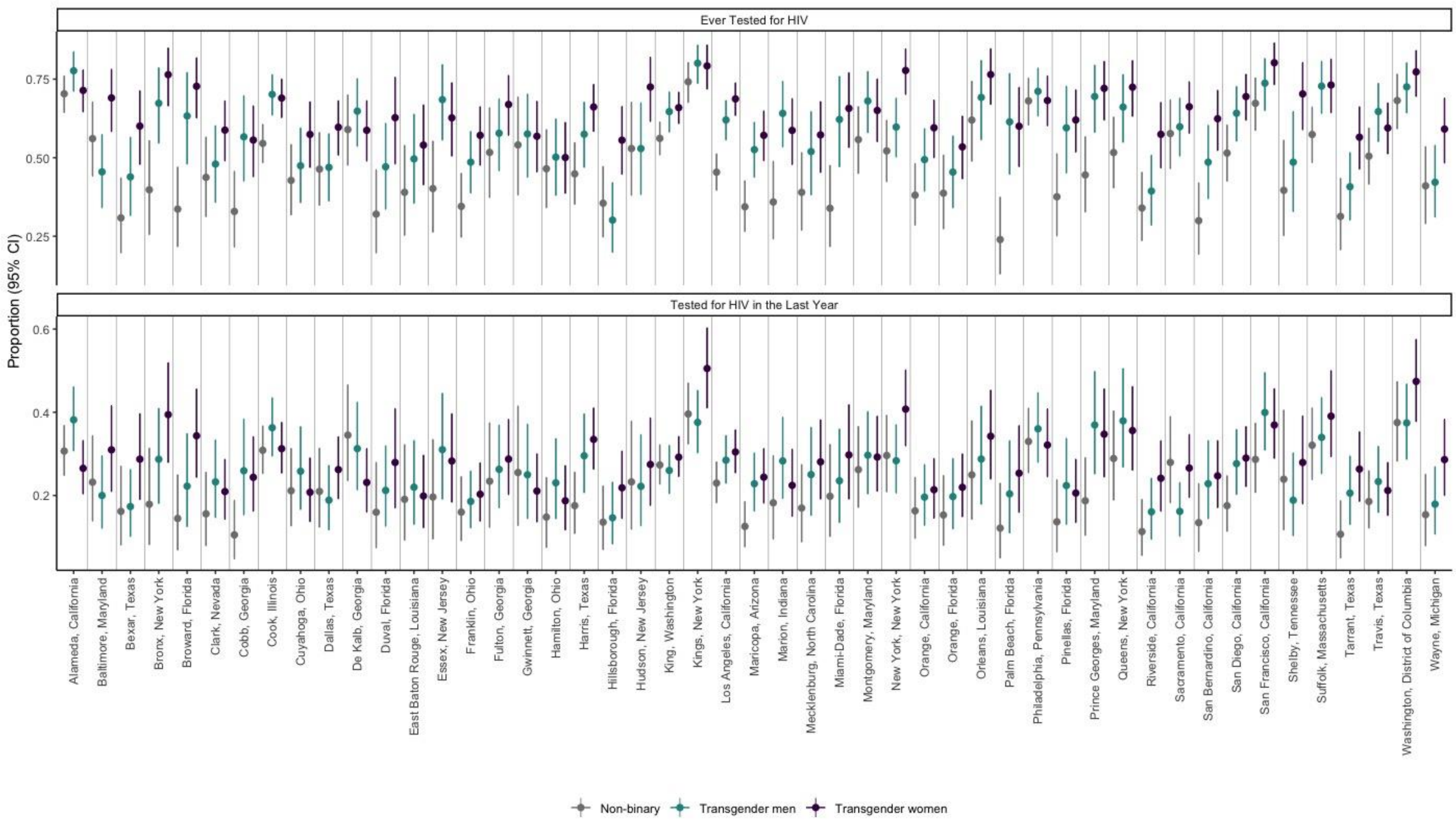
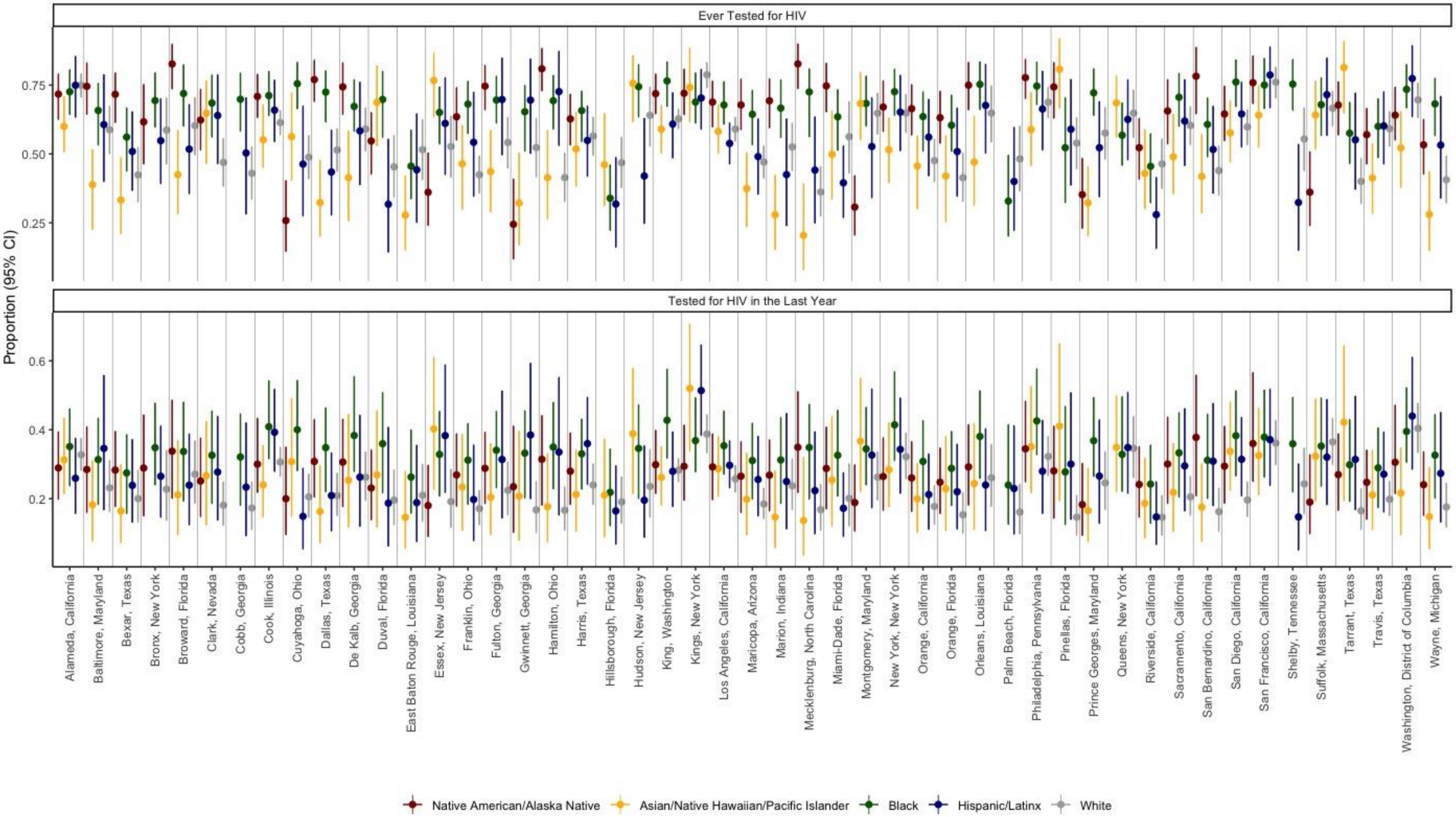


Figure 1.2. Proportion of Transgender and Non-binary Adults who have Tested for HIV among Counties Prioritized by the Ending the HIV Epidemic Initiative, 2015 US Transgender Survey

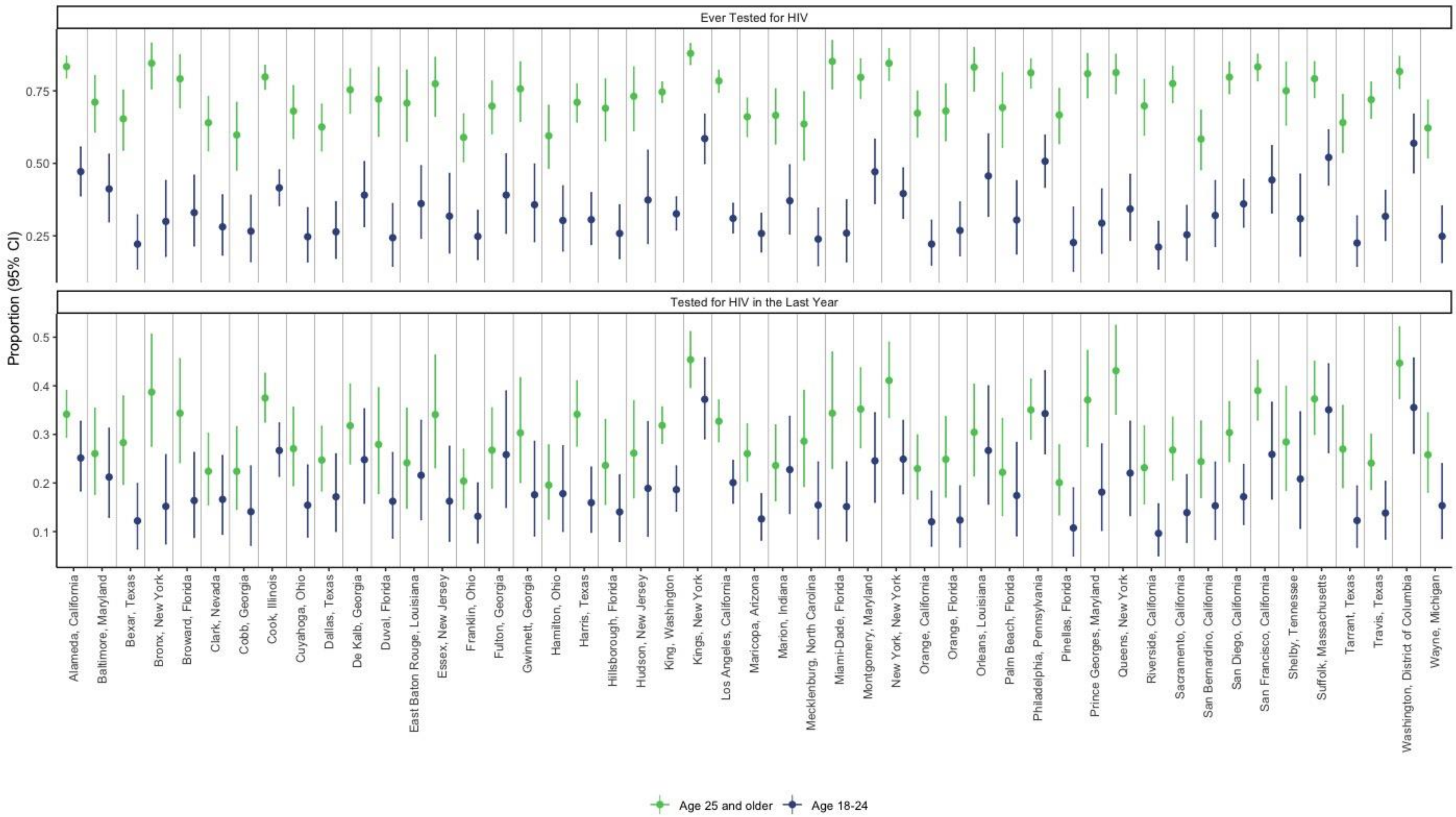
A. Subgroup Analysis by Gender Identity



B. Subgroup Analysis by Race/Ethnicity



C. Subgroup Analysis by Age



Chapter 2: An Intercategorical Quantitative Intersectionality Analysis of HIV/STI Prevention and Healthcare Access among Transgender and Non-binary People in Washington State

ABSTRACT

Background: We applied descriptive quantitative intersectional methods to examine difference in HIV/STI prevention, healthcare access, and socio-structural factors associated with poverty within transgender and non-binary (TNB) communities in Washington state.

Methods: We pooled data from five 2019-2021 Washington State HIV/STI surveillance data sources to obtain a large and diverse sample. We calculated the risk difference (RD) for each outcome and used Poisson regression to estimate surrogate measures of additive interaction--the attributable proportion (AP).

Results: Among 1648 TNB participants, there were overall high levels of poverty (29% incomes <$15,000, 7% unstable housing) and structural barriers to accessing healthcare (8% uninsured, 23% no regular doctor/provider). Certain groups, especially trans women of color, were disproportionately impacted by poor socioeconomic outcomes, barriers to care, and HIV/STIs, more than what would have been expected based on gendered or racialized experience alone (APs ranging from 50-95%). HIV/STI testing and PrEP access was lowest among trans men and non-binary people AFAB.

Conclusions: Our findings highlight the need expand access to trans-inclusive models of HIV/STI prevention and PrEP delivery that address multilevel barriers rooted in cissexism and structural racism.

INTRODUCTION

Transgender and non-binary (TNB) people experience significant barriers to accessing healthcare, including HIV/STI prevention tools. These barriers result from structural inequities rooted in cissexism, whereby TNB people disproportionately experience socioeconomic disadvantages, discrimination, and frequently lack access to trans-competent providers and insurance coverage.[3,21,74,75] Consequently, HIV/STI testing, pre-exposure prophylaxis (PrEP) uptake, antiretroviral therapy (ART) coverage, and viral suppression are low in TNB communities relative to cisgender populations.[13,16,18,19,46,76–80] These same socio-structural inequities can also increase TNB people's vulnerability to HIV/STI acquisition, through decreased access to HIV/STI prevention tools and higher prevalence of syndemic factors (e.g., unstable housing, sex work, and substance use).[81–83] A recent meta-analysis reported HIV prevalence of 19% among trans women and 2% among trans men in the U.S.[5] The same meta-analysis also estimated that 21% of trans women and 29% of trans men self-reported having a prior STI diagnosis.[5]

There are also significant racial inequities within TNB populations, whereby ethnoracial minority TNB people disproportionately experience discrimination in healthcare setting, structural barriers to care (e.g., financial, limited providers), and poor health outcomes (e.g., cardiovascular disease, depression).[84–93] Significant racial disparities in HIV prevalence among trans women have been well documented. For example, 2019 National HIV Behavioral Surveillance data collected across 7 US cities revealed that HIV prevalence was highest among Native American (65%), Black (62%) and Hispanic/Latina (35%) trans women, and lowest among White trans women (17%).[60] Similarly, data from the National HIV Surveillance System suggests that there are significant racial disparities in HIV diagnoses among trans men: the majority of trans men living with HIV were Black (41.3%), Hispanic (26.1%) or Multiracial (6.5%), and 23.9% were White.[64] However, HIV/STI-related data for trans men disaggregated by race/ethnicity remain relatively scarce, and data are virtually non-existent for non-binary people.[3,5,64,94]

This study applied quantitative intersectional methods to further examine difference in HIV/STI prevention, healthcare access, and socio-structural factors associated with poverty within TNB communities. Our analysis leveraged data pooled from multiple Washington State HIV/STI surveillance data sources to describe the heterogeneity in outcomes among TNB participants by gender, race, and ethnicity.

METHODS

Theoretical and Methodological Frameworks

This analysis is guided by the Intersectionality Research for Transgender Health Justice (IRTHJ) framework.[95] Drawing on intersectionality theory and structural injustice, IRTHJ is a conceptual model that describes how interlocking structures of domination (e.g., cissexism, white supremacy, colonialism, classism) are enacted through institutional systems and socio-structural practices to produce material and health inequities for transgender people. Intersectionality theory, which was originally coined in 1989 and developed as an analytic tool by Kimberlé Chrenshaw and Patricia Hill Collins, grew out of Black feminist thought of the 19th and 20th centuries, and has since traveled across numerous academic disciplines and social justice movements.[96–99] A central tenet of intersectionality is that social categories like gender, race, and ethnicity, are not independent but are instead interdependent and mutually constitutive. That is, intersectionality examines how macro-level systems of power and privilege jointly shape the experience of individuals living at those intersections.[97] The concept of intersectionality stands in contrast to unidimensional or single axis approaches, which assumes that effects at an intersection of identities is more simply understood as a sum of their parts.

The present study is a descriptive intersectional analysis that focuses on understanding how outcomes—specifically measures of socio-structural factors associated with poverty, healthcare access, and HIV/STI prevention—are heterogeneous for TNB people across two axes: gender and race/ethnicity. Drawing upon McCall's framework for managing intersectional complexity, we characterize the present analysis as primarily intercategorical.[100] *Inter*categorical intersectional analyses explore whether meaningful inequities exist among already defined socially constructed groups or identities using methods of systematic comparison. This is to be contrasted with *intra*categorical approaches, which focus on a specific social group in order to reveal the complexity of lived experience within such group, and *anti*categorical approaches, which challenge or deconstruct social categorization altogether as too simplistic to capture the complexity of lived experience.

Although we utilize individual-level data, the present analysis situates observed population-level patterns of inequities within systems of power and oppression, and not as individual-level outcomes. Therefore, we consider race/ethnicity as a proxy for exposure to structural and individual experiences of racism[101,102] and we use gender as proxy for exposure to structural and individual experiences of cissexism and anti-trans bias, as they may be experienced differently by trans men, trans women, non-binary and gender non-conforming people. This interpretation is consistent with IRTHJ and empirical data on experiences of discrimination and stigma among ethnoracial minority TNB people.[75,83,88,90,91,103,104]

Lastly, in line with IRTHJ's call to center embodied knowledge, this analysis was conducted in collaboration the Seattle Trans and Non-binary Sexual Health (STARS) Advisory

Board, a community advisory group of 9 TNB people from the Seattle area that met bimonthly between February 2021 and July 2022.

Data sources and study population

Our study population includes TNB people in Washington state (WA) who participated in one of five cross-sectional surveys conducted by Public Health – Seattle & King County (PHSKC) or who visited the PHSKC Sexual Health Clinic located in Seattle, WA.

PHSKC Pride Surveys. We utilized three years of data (2019, 2020, and 2021) from PHSKC's Pride Survey, an annual survey conducted for surveillance purposes through PHSKC's HIV/STD Program. The 2019 Pride Survey recruited participants in person during two Pride Events in Seattle. Participants were eligible if they lived in WA and either identified as TNB or as men who have sex with men. Participants in the 2019 Pride Survey completed an anonymous paper survey, and were given a small incentive (condoms, lube, and a $5 coffee gift card) after completing the survey. Due to the COVID-19 pandemic, the 2020 and 2021 Pride Surveys were conducted online through an anonymous REDCap survey and recruited participants through social media (Instagram, Facebook, Twitter), virtual pride events, in-person COVID-19 vaccine clinics, and fliers. The inclusion criteria for the 2020 and 2021 Pride Surveys were expanded to include any LGBTQ+ people who lived in WA.

National HIV Behavioral Surveillance (NHBS). The NHBS survey is coordinated by the Centers for Disease Control and Prevention (CDC) across 22 cities, including Seattle. Surveillance is conducted annually and rotates through different populations with a higher likelihood of HIV acquisition. We utilized Seattle site data from the first NHBS cycle conducted among trans women and non-binary people assigned male at birth (AMAB) in 2019, locally called *Project First.* This study recruited participants using respondent driven sampling and data were collected via an in-person interview.

PHSKC Sexual Health Clinic. The PHSKC Sexual Health Clinic in Seattle provides walk-in STI/HIV testing and treatment on a sliding fee basis. All new patients complete a computer-assisted self-interview which includes information on demographics, HIV/STI history, and sexual behaviors. We utilized de-identified data from patients who attended the Sexual Health Clinic from January 2019 through February 2020. For patients who had multiple clinic visits, we restricted our analysis to a patient's first visit during the study period.

Measures

All data sources used identical or similar questions to ascertain the following measures:

Gender Identity and Sex Assigned at Birth. All data sources used a validated trans-inclusive two-step question for ascertaining gender identity, which asks about both current gender and sex assigned at birth using two distinct questions. All surveys provided non-binary and write-in response options, however these options differed slightly across surveys. Therefore, for this analysis we use the term non-binary as an umbrella term that includes participants who self-reported being non-binary, genderqueer, gender nonconforming, and additional write-in identities. For our analyses, we consider the following groups of participants: trans men, trans women, non-binary people assigned male at birth (AMAB), and non-binary people assigned female at birth (AFAB). We chose to disaggregate non-binary people by their sex assigned at birth due to prior research demonstrating differences in the epidemiology of HIV/STIs among non-binary people by sex assigned at birth.[105]

Race/ethnicity. Self-reported race/ethnicity categories included Asian, Black, Hispanic/Latinx, Native American/Alaska Native, and Native Hawaiian/Pacific Islander (NHPI).

Participants who selected more than one race/ethnicity were included in multiple categories for descriptive statistics and statistical analyses.

Socio-structural factors associated with poverty & healthcare access. We considered four binary outcome variables related to potential socio-structural barriers to care: (1) annual incomes <$15,000, which is near the national poverty line ($13,171 for a one-person household), (2) Unstable housing or living homeless in the past year, (3) not having medical insurance, or (4) not having a regular doctor/provider. These variables were not available in data collected from the Sexual Health Clinic.

HIV/STI-related outcomes. We considered four binary outcome variables related to HIV/STIs: (1) a composite measure of HIV/STI positivity for individuals who self-reported being HIV positive or being diagnosed with a bacterial STI (i.e. chlamydia, gonorrhea, or syphilis) in the last 12 months, (2) a composite measure of self-reported testing for HIV and/or bacterial STIs in the last 12 months, (3) ever discussing PrEP with a doctor/provider, and (4) self-reported current PrEP use. History of STI testing in the last 12 months is not available in data from PSHKC Sexual Health Clinic.

Analyses

We define groups (i.e., intersectional positions) based on self-reported gender and race/ethnicity. We also selected White trans men as the reference group. Typically, the choice of reference groups in quantitative intersectionality analysis aims to reflect intersectional positions with the greatest privilege/power. In considering the impacts of structural racism and colonization, we chose White participants as the reference group. However, the choice of reference group along the axis of gender identity was more challenging. All trans and non-binary people experience disadvantages relative to cisgender people as result of cissexism and anti-trans stigma. However, trans and non-binary people are impacted in different ways through systems of power rooted is sexism (i.e., transmisogyny) and the gender binary. For example, trans women experience trans misogyny in a very different way than trans men and non-binary people. In addition, individuals with binary identities (i.e., trans men and women) may be privileged in some contexts compared to non-binary people. At the same time, the majority of health research (especially HIV/STI related research) has focused on trans women, while trans men and non-binary people are significantly underrepresented in health research. Through conversations with the STARS Advisory Board, we ultimately chose trans men as our reference group since they were the second largest gender group and had the lowest prevalence of many (but not all) of the outcomes of interest. However, it is important to acknowledge that trans men do not represent the "least marginalized" or "most privileged" group. Rather, choice of a reference group allows us to better understand heterogeneity within trans communities. Through conversations with the STARS Advisory Board, choosing a reference group from within TNB communities was preferred to comparing transgender people to a cisgender reference group—a common practice which often reifies cisgender-normativity.

We used statistical methods to quantify differences in outcomes on the additive statistical scale, which is most consistent with the concept of intersectional multiplicativity.[106,107] Assessing differences on the additive scale allows statistical interaction to be translated in measures of excess prevalence, and is thus also the most relevant measure for assessing public health impact. For each outcome, we calculated the risk difference (RD) for all groups relative to White trans men using binomial regression with an identity link. For trans women and non-binary participants of color (i.e., for groups with dual positional differences relative to the reference group of White trans men), we also estimated surrogate measures of intersectional synergism/antagonism--the attributable proportion (AP) due the intersection.[108] The AP estimates the proportion of the excess prevalence of the outcome that can be attributed to the intersection of gendered and racialized experience, beyond what would be expected from gender or race/ethnicity alone. These two measures were chosen for their clear interpretability (Figure 2.1). We estimated three additional surrogate measures of intersectionality on the additive scale: the ratio of observed to expected relative joint effects (RJE), the relative excess risk due to interaction (RERI), and the synergy index (SI). These analyses are presented in the Appendix B. We used Poisson regression with robust standard errors to estimate the AP, RJE, RERI, and SI.

We restricted the analyses of past year HIV/STI testing to sexually active participants who reported any oral, vaginal/front hole, or anal sex in the past year. To be consistent with the CDC's 2021 updated clinical practice guidelines for identifying patients who should be prescribed PrEP or discuss PrEP with a provider, we restricted the analysis of current PrEP use to HIV-negative participants who reported any vaginal/front hole or anal sex in the past year. Analyses of HIV/STI positivity, socio-structural factors, and barriers to healthcare were conducted among all participants. All models adjusted for participant age. We estimated standard errors and 95% confidence intervals using the delta method. Confidence intervals that do not span 1.0 are statistically significant with a type I error rate of $\alpha = 0.05$. We only interpret APs as being of public health importance when the associated RDs are also statistically significant. Mathematical details are presented in Appendix B.[108,109]

All analyses were conducted in R statistical software. Ethical approval was received from the University of Washington Institutional Review Board.

RESULTS

Our analysis included 1648 TNB participants, including 317 (19.2%) trans men, 363 (22.0%) trans women, 242 (14.7%) non-binary people AMAB, and 726 (44.1%) non-binary people AFAB (Supplemental Table 2.2). With respect to race/ethnicity, 143 (8.7%) of participants were Asian, 95 (5.8%) were Black, 177 (10.7%) were Hispanic/Latinx, 88 (5.3%) were Native American/Alaska Native, 67 (4.1%) were NHPI, and 1172 (71.1%) were White. In addition, 156 (9.3%) participants selected more than one race or ethnicity and 137 (8.1%) participants were missing data for race/ethnicity. The study population primarily included adults age 25 or older (n=1176, 72.4%), while 448 (27.6%) participants were adolescents and young adults age 13-24 (Supplemental Tables 2.2 and 2.3).

Socio-Structural Factors Associated with Poverty & Healthcare Access

Overall, 29% of participants were living close to or below the poverty line with annual incomes below $15,000 (range 0-57% across groups) and 7% experienced unstable housing in the past year (range 0-71%; Figure 2.2). In addition, 10% of participants were uninsured (range 0-43% across groups) and 23% reported that they did not have a regular doctor or provider (range 0-58%).

Relative to White trans men, Black trans women were more likely report incomes below $15,000 (48%; RD 0.22; Table 2.1), unstable housing (28%; RD 0.24), and not having a regular doctor (48%; RD 0.31; Table 2.2). NHPI trans women were more likely to report unstable housing (18%; RD 0.15), lack of health insurance (34%; RD 0.31), and not having a regular doctor (48%; RD 0.32). Asian, Latinx, and Native American trans women were also more likely to lack health insurance (28-43%; RDs 0.25-0.39). From the AP, we estimated that 74-93% of the excess prevalence of being uninsured among trans women of color, 64% of the excess prevalence of not having a regular doctor among Black trans women, and 67% of the higher prevalence of unstable housing among NHPI trans women was attributable to the intersection of racialized and gendered experience.

Notably, one of the smaller groups of Black non-binary people AMAB (n=7) had starkly higher prevalence's of poverty (57%; RD 0.33) and unstable housing (71%; RD 0.68). Despite small sample sizes, we estimated statistically significant APs suggesting the majority (61-89%) of this excess prevalence of these socio-structural factors was attributable to intersectional experience.

HIV/STI Positivity

Self-reported HIV prevalence was 7% among trans women and non-binary people AMAB. There were no trans men and 2 (0.3%) non-binary people AFAB who self-reported being HIV-positive. Non-binary people AMAB had the highest prevalence of past year STIs (34%; Supplemental Table 2.3). Trans men and women had a similar prevalence of past year STI diagnoses (16% and 15% respectively), and non-binary people AFAB had the lowest prevalence (6%). There were no statistically significant differences in HIV prevalence by race/ethnicity among trans men and non-binary participants (Supplemental Table 2.4). However, among trans women, HIV prevalence was highest among Black, Hispanic/Latinx, and NHPI women (28%, 15%, and 10%, respectively) and lowest among White and Asian women (3% and 0%, respectively). A similar pattern was observed for recent STI diagnoses among trans women. (See Supplemental Table 2.4 for disaggregated data on HIV, chlamydia, gonorrhea, and syphilis.)

Relative to White trans men, there were statistically significant higher RDs in HIV/STI positivity among Black, Latinx, and NHPI trans women (RD range 0.20-0.43; Table 2.3), as well as among non-binary people AMAB who were White, Asian, Black, and Latinx (RD range 0.27-

0.46). From the AP, we estimated that 50%, 67%, and 85% of the excess HIV/STI prevalence among Black, Latinx, and NHPI trans women, respectively, was attributable to the intersection of racialized and gendered experience.

HIV/STI Testing

Overall, 68% of participants had ever tested for HIV. Among sexually active participants who reported any oral, vaginal/front hole, or anal sex in the past year, 45% has tested for HIV in the last year, and 43% tested for STIs in the last year. Past year HIV/STI testing was highest among Black trans men (75%; RD 0.33; Table 2.3), all trans women of color (72-88%; RD range 0.31-0.46), as well as among Black, Latinx, and Native American/Alaska Native non-binary people AMAB (69-100%; RD range 0.25-0.60). However, there was only statically significant evidence of intersectional synergism in past year HIV/STI testing for several of these groups. Specifically, we estimated that 41% and 74% of the higher prevalence of past year HIV/STI testing among Latinx and NHPI trans women, respectively, was attributable to the intersection of racialized and gendered experience.

PrEP

Overall, 84% of all participants had ever heard of PrEP. Among HIV negative participants who reported any vaginal/front hole or anal sex in the past year, 21% had ever discussed PrEP with a provider (range 0-67% across groups; Figure 2.3). Compared to White trans men, a higher proportion of Asian trans men had ever discussed PrEP with a provider (56%; RD 0.37; Table 2.4). There were also statistically significant higher proportion of Black, Native American/Alaska Native, and NHPI trans women (RD range 23-36%) as well as Black, Latinx, and Native American/Alaska Native non-binary people AMAB (RD range 27-36%; Table 2.4) who had ever discussed PrEP with their provider. Latinx trans men (5%) and non-binary people AFAB overall (12%) were least likely to have ever discussed PrEP with a provider, although these RDs were not statistically significant. From the AP, we estimated that 83% of the higher prevalence of ever discussing PrEP among NHPI trans women was attributable to the intersection of racialized and gendered experience.

Among HIV-negative participants who reported any vaginal/front hole or anal sex in the past year, 8% reported current PrEP use (range 0-46% across groups). Current PrEP use was lowest among trans men (5%) and non-binary people AFAB (2%). Current PrEP use was highest among trans women of color (21-46%; RD range 0.17-0.42) and Latinx non-binary people AMAB (40%; RD 0.36). Relative to White trans men, we estimated that 58% and 89% of the higher prevalence of current PrEP use among Latinx and Native American/Alaska Native trans women, respectively, as well as 58% of the higher prevalence of current PrEP use among Latinx non-binary people AMAB was attributable to the intersection of racialized and gendered experience.

DISCUSSION

Structural racism and cissexism are ubiquitous forces enacted at multiple social and institutional levels and produce socioeconomic inequity and adverse health outcomes for transgender people. Our findings demonstrate the differential impacts of racialized and gendered experiences on HIV/STI positivity and healthcare access, including HIV/STI prevention, for TNB people in WA. We observed high levels of poverty and structural barriers to accessing healthcare among all TNB participants. However, we observed that certain groups, especially trans women of color, were disproportionately impacted by poor socioeconomic outcomes, barriers to care, and HIV/STIs, more than what would have been expected based on gender or race/ethnicity alone. We also observed significant heterogeneity HIV/STI prevention utilization, with the lowest levels of HIV/STI testing and PrEP access among trans men and non-binary people AFAB.

Specifically, trans women and non-binary people AMAB who were Black, Latinx, Native American, and NHPI were significantly more likely to be uninsured and not have a regular doctor. We estimated that a large proportion of these inequities among trans women of color—over 60%—was explained by intersectional synergism; that is, it was higher than what would have been expected from racialized and/or gendered experiences of cissexism alone. This is consistent with prior research which found that Black and Hispanic transgender people are more likely to report financial barriers to healthcare and are less likely to have a regular doctor compared to White transgender people.[84,86] Our findings are also consistent with prior studies which found significant disparities in insurance access for Hispanic transgender adults, but a similar prevalence of insurance coverage for Black and White transgender adults.[84,86]

We also estimated that a large proportion (50-89%) of the higher HIV/STI prevalence among trans women of color was explained by intersection of racialized and gendered experience. However, this also corresponded with high levels of past year HIV/STI testing and PrEP use among HIV-negative trans women of color. Non-binary people AMAB who were White, Asian, Black and Latinx also had high prevalence of self-reported HIV/STI positivity, testing and PrEP use; but there was no empirical evidence that the prevalence was higher than what would be expected from the individual (e.g. non-synergistic) contributions of racialized and/or gendered experience.

Lastly, there were significant inequities in PrEP access among TNB participants. Among all participants who reported any vaginal/front hole or anal sex in the past year, only 1 in 5 had ever discussed PrEP with a provider. This points to significant missed opportunity for providers to discuss PrEP with TNB patients, especially with non-binary people AFAB and White, Latinx, and NHPI trans men. Current PrEP use ranged from >40% among Native American trans women and Latinx non-binary people AMAB to <10% among the majority of the subgroups defined by gender and race/ethnicity. Notably, the prevalence of current PrEP use among trans men in our sample (5%) was much lower than what has been reported in other studies (18-22%).[61,63]

Quantitative intersectionality analyses require large sample sizes, which has historically been a barrier to conducting trans health research. This study obtained a sufficiently large and diverse sample of TNB people by pooling data from multiple existing HIV/STI surveillance data sources. Thus, a strength of the present analysis is our ability to present disaggregated data for non-binary people, as well as for racial groups for whom data are not typically disaggregated in trans health research due to small samples sizes—namely data for Native American/Alaska Native and NHPI participants. Nonetheless, some groups defined by gender and race/ethnicity still had relatively small samples of 10 or fewer for several outcomes (i.e., Black, Native American, and NHPI trans men and non-binary people AMAB). Therefore, it is likely that at least some of the observed heterogeneity is due instability in our estimates due to smaller sample sizes.

Our findings should also be interpreted in light of the following limitations. The data uses 4 convenience samples and 1 clinical sample, and therefore may not be representative. In addition, we rely on self-report for past year HIV/STI, past year STI diagnosis, and HIV status which are all vulnerable to recall bias. In addition, because these data sources were primarily used for local HIV/STI surveillance, they did not systematically collect data on topics that were important to the lived experiences of transgender people or their unique barriers to accessing care, such as experiences of discrimination and access to gender-affirming care. Some of these studies, such as the NHBS and 2021 Pride Study, did collect data on some trans-specific topics, but they were not collected using consistent enough measures or with sufficiently large sample sizes with which to conduct intersectional analyses.

Conclusion

Intersectional research with TNB populations is important for identifying and addressing inequities among communities that live at these intersections. Our study highlights how quantitative intersectionality methods can also reveal heterogeneity in healthcare access and HIV/STI prevention utilization within TNB communities by gender and race/ethnicity. Importantly, we identified inequities in HIV/STI testing, current PrEP use, and missed opportunities for providers to discuss PrEP within TNB communities. These findings highlight the need expand access to trans-inclusive models[62,77,110,111] of HIV/STI prevention and PrEP delivery that address multilevel barriers rooted in cissexism and structural racism.

TABLES & FIGURES

Figure 2.1. Schematic of Risk Difference and Attributable Proportion for Quantitative Intercategorical Intersectionality Analyses by Gender and Race/Ethnicity

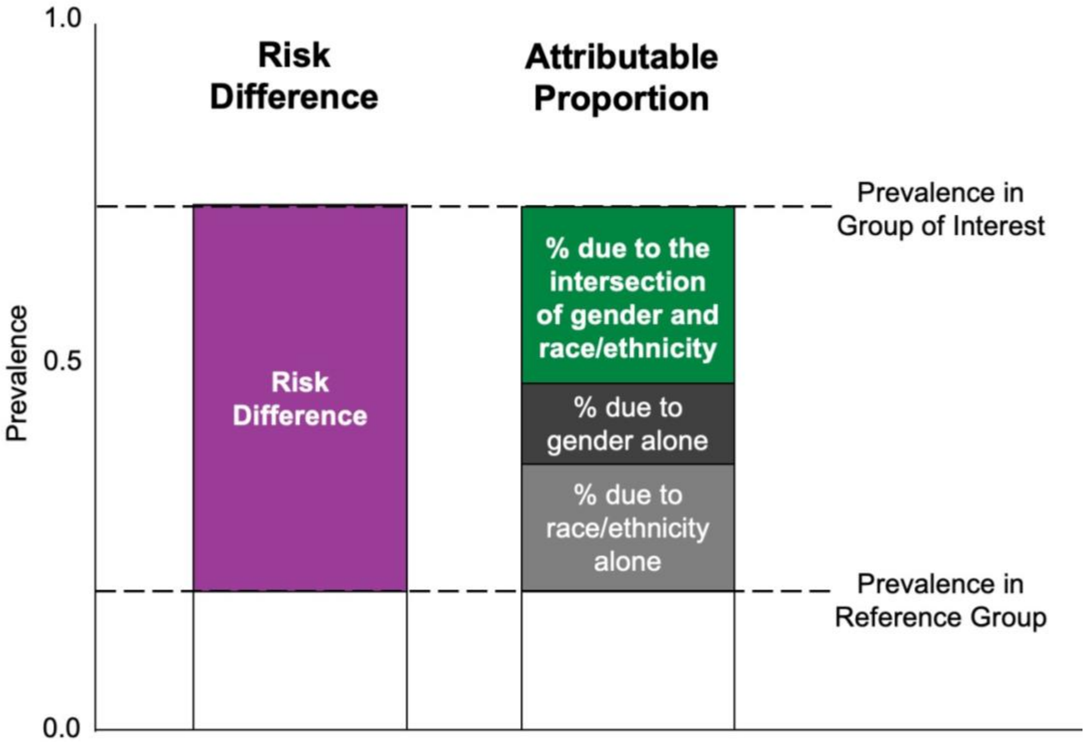


Figure 2.2. Socio-structural Factors and Health Care Access Among Transgender and Non-binary Participants, Washington State, 2019-2022. *AFAB, assigned female at birth; AMAB, assigned male at birth.*

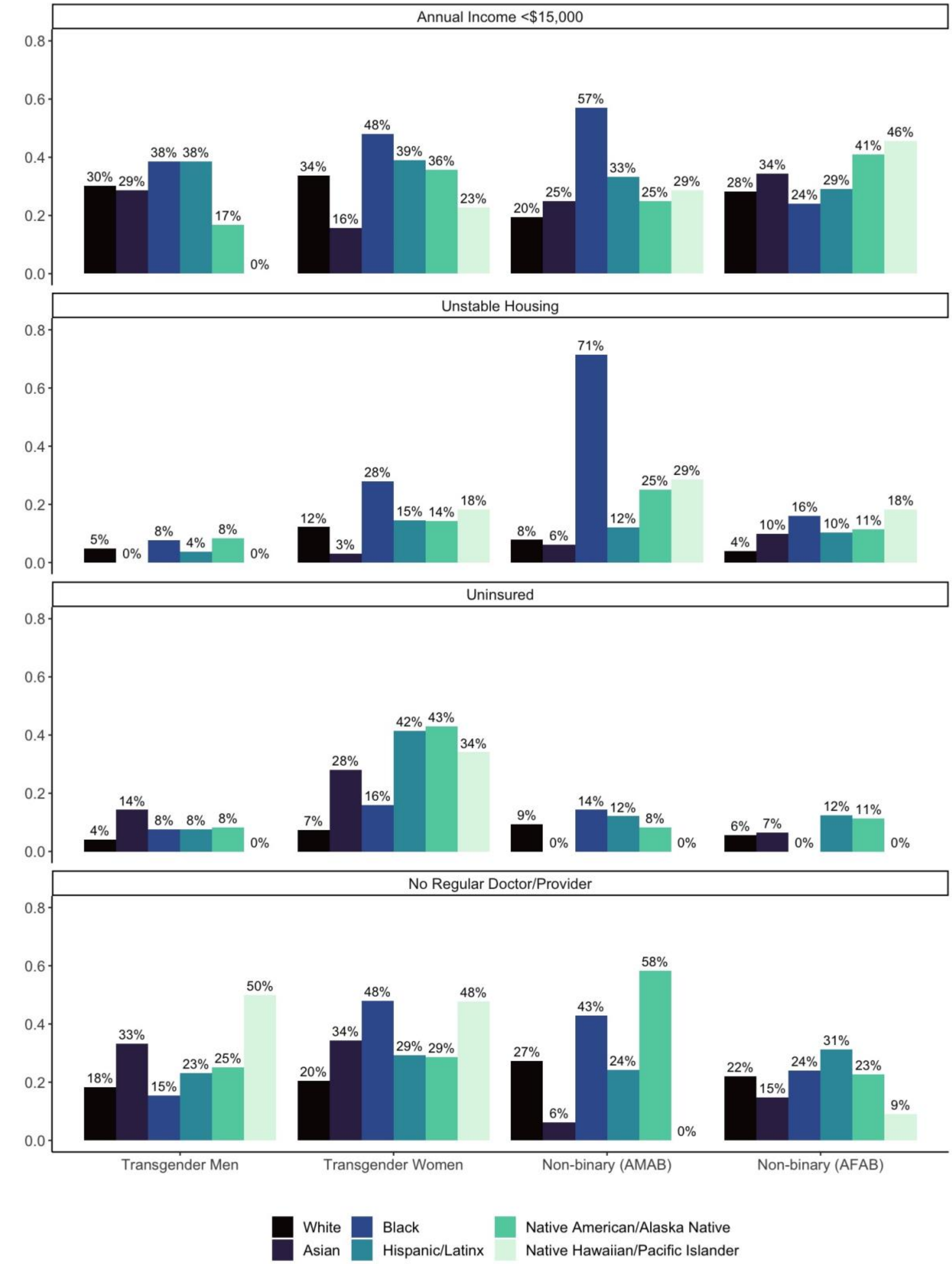


Figure 2.3. HIV/STI Positivity, Testing and PrEP Among Transgender and Non-binary Participants, Washington State, 2019-2022. *AFAB, assigned female at birth; AMAB, assigned male at birth; PrEP, pre-exposure prophylaxis; STI, sexually transmitted infection.*

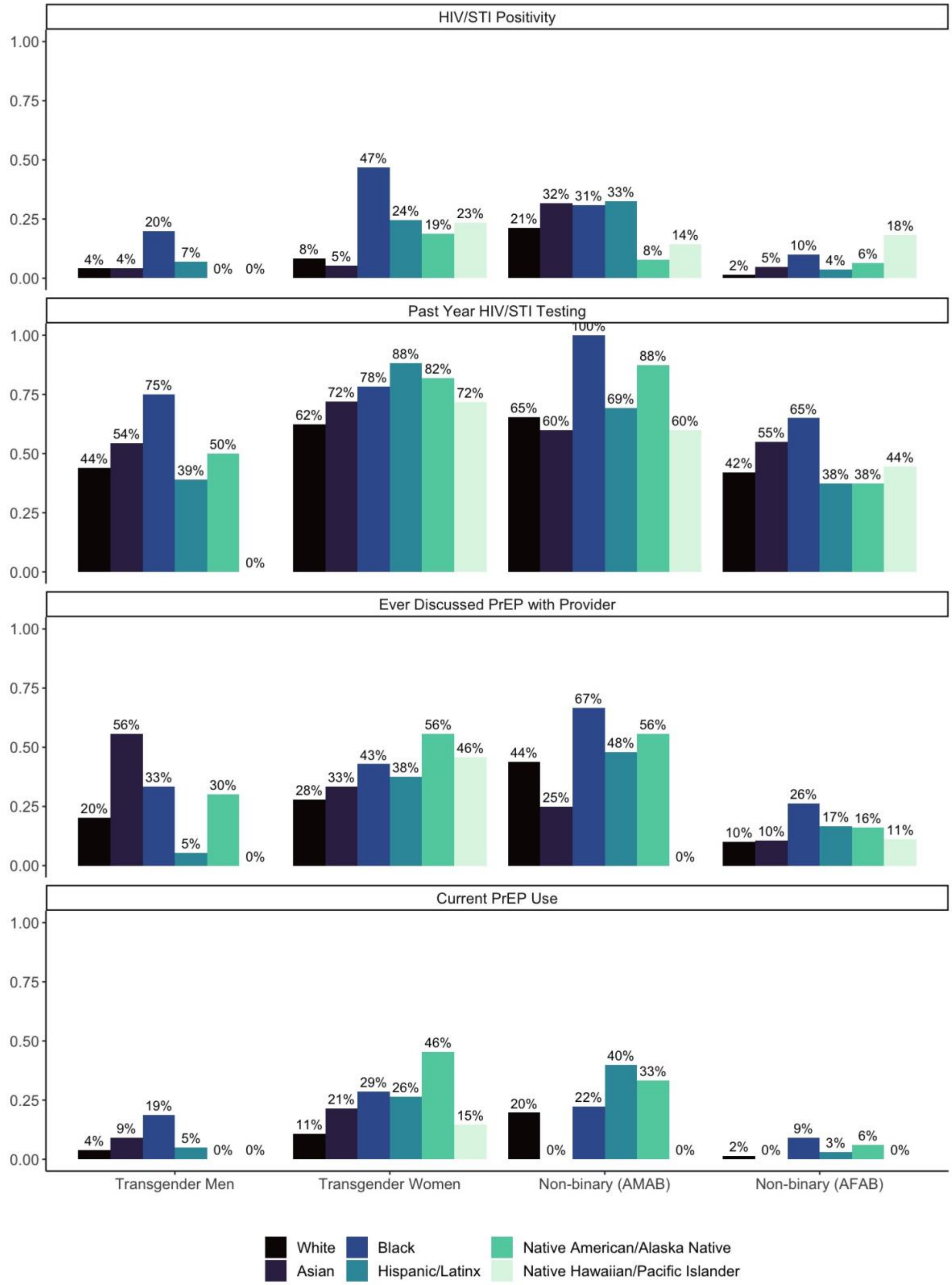


Table 2.1. Intersectionality Analysis for Low Income and Unstable Housing among Transgender and Non-binary People in Washington State, 2019-2021

		Annual Income <$15,000			**Unstable Housing**		
	N	n (%)	RD (95% CI)	AP (95% CI)	n (%)	RD (95% CI)	AP (95% CI)
Overall	1442	412 (28.6)			98 (6.8)		
Trans Men							
White [ref]	251	76 (30.3)	ref		12 (4.8)	ref	
Asian	21	6 (28.6)	-0.13 (-0.33, 0.06)		0 (0.0)	-0.07 (-0.10, -0.04)	
Black	13	5 (38.5)	0.06 (-0.18, 0.30)		1 (7.7)	0.03 (-0.12, 0.17)	
Latinx	26	10 (38.5)	0.01 (-0.17, 0.20)		1 (3.8)	-0.02 (-0.10, 0.06)	
Native American/Alaska Native	12	2 (16.7)	-0.13 (-0.32, 0.05)		1 (8.3)	0.04 (-0.12, 0.20)	
Native Hawaiian/Pacific Islander	2	0 (0.0)	-0.20 (-0.26, -0.14)		0 (0.0)	-0.03 (-0.06, 0.00)	
Trans Women							
White	205	69 (33.7)	-0.29 (-0.66, 0.08)		25 (12.2)	0.03 (0.00, 0.06)	
Asian	32	5 (15.6)	-0.11 (-0.24, 0.02)	-0.56 (-2.05, 0.94)	1 (3.1)	-0.01 (-0.08, 0.06)	-1.41 (-6.40, 3.58)
Black	25	12 (48.0)	**0.22 (0.02, 0.42)**	0.20 (-0.34, 0.74)	7 (28.0)	**0.24 (0.06, 0.42)**	0.48 (-0.10, 1.06)
Latinx	41	16 (39.0)	0.14 (-0.02, 0.31)	0.16 (-0.33, 0.66)	6 (14.6)	0.11 (0.00, 0.22)	0.33 (-0.37, 1.03)
Native American/Alaska Native	14	5 (35.7)	0.05 (-0.19, 0.29)	0.36 (-0.38, 1.09)	2 (14.3)	0.10 (-0.08, 0.28)	-0.20 (-2.08, 1.68)
Native Hawaiian/Pacific Islander	44	10 (22.7)	0.02 (-0.12, 0.15)	0.78 (0.48, 1.08)	8 (18.2)	**0.15 (0.03, 0.27)**	**0.67 (0.36, 0.98)**
Non-binary AMAB							
White	128	25 (19.5)	-0.17 (-0.63, 0.29)		10 (7.8)	**0.04 (0.01, 0.07)**	
Asian	16	4 (25.0)	0.04 (-0.18, 0.26)	**0.67 (0.20, 1.14)**	1 (6.2)	0.03 (-0.09, 0.15)	0.61 (-0.67, 1.88)
Black	7	4 (57.1)	**0.33 (0.02, 0.69)**	**0.61 (0.31, 0.92)**	5 (71.4)	**0.68 (0.35, 1.01)**	**0.89 (0.78, 1.00)**
Latinx	33	11 (33.3)	0.07 (-0.12, 0.25)	0.35 (-0.11, 0.82)	4 (12.1)	0.08 (-0.04, 0.19)	0.44 (-0.32, 1.20)
Native American/Alaska Native	12	3 (25.0)	0.00 (-0.25, 0.24)	**0.68 (0.03, 1.33)**	3 (25.0)	0.21 (-0.03, 0.46)	0.57 (0.00, 1.14)
Native Hawaiian/Pacific Islander	7	2 (28.6)	0.09 (-0.25, 0.43)	1.17 (1.01, 1.34)	2 (28.6)	0.26 (-0.08, 0.59)	**0.93 (0.77, 1.10)**
Non-binary AFAB							
White	587	166 (28.3)	-0.09 (-0.48, 0.31)		23 (3.9)	0.06 (-0.02, 0.14)	
Asian	61	21 (34.4)	0.03 (-0.11, 0.16)	0.38 (-0.06, 0.82)	6 (9.8)	0.05 (-0.03, 0.13)	1.16 (0.93, 1.38)
Black	25	6 (24.0)	-0.10 (-0.27, 0.07)	-0.76 (-2.20, 0.69)	4 (16.0)	0.11 (-0.03, 0.25)	**0.54 (0.11, 0.96)**
Latinx	48	14 (29.2)	0.01 (-0.12, 0.14)	-0.07 (-0.68, 0.55)	5 (10.4)	0.06 (-0.03, 0.15)	**0.77 (0.42, 1.12)**
Native American/Alaska Native	44	18 (40.9)	0.12 (-0.03, 0.28)	0.62 (0.20, 1.04)	5 (11.4)	0.07 (-0.02, 0.17)	0.35 (-0.19, 0.89)
Native Hawaiian/Pacific Islander	11	5 (45.5)	0.16 (-0.12, 0.43)	0.98 (0.81, 1.14)	2 (18.2)	0.14 (-0.09, 0.36)	**1.04 (0.87, 1.22)**

AFAB, assigned female at birth; AMAB, assigned male at birth; AR, attributable risk; CI, confidence interval; RD, risk difference.
This table excludes data collected from the Public Health-Seattle & King County Sexual Health Clinic, which did not collect data on income or unstable housing. Measures of RD and AP are adjusted for participant age. The null value for the RD and AP is 0 and the reference for group is White transgender men. Bolded numbers indicate statistically significant results in which 95% CI's that don't contain the null.

Table 2.2. Intersectionality Analysis of Medical Insurance and Access to a Regular Doctor/Provider among Transgender and Non-binary People in Washington State, 2019-2021

		Uninsured			**No Regular Doctor/Provider**		
	N	n (%)	RD (95% CI)	AP (95% CI)	n (%)	RD (95% CI)	AP (95% CI)
Overall	1442	121 (8.4)			337 (23.4)		
Trans Men							
White [ref]	251	10 (4.0)	ref		46 (18.3)	ref	
Asian	21	3 (14.3)	0.10 (-0.05, 0.25)		7 (33.3)	0.12 (-0.09, 0.34)	
Black	13	1 (7.7)	0.04 (-0.11, 0.18)		2 (15.4)	-0.03 (-0.23, 0.16)	
Latinx	26	2 (7.7)	0.04 (-0.07, 0.15)		6 (23.1)	0.03 (-0.14, 0.20)	
Native American/Alaska Native	12	1 (8.3)	0.05 (-0.11, 0.20)		3 (25.0)	0.07 (-0.18, 0.33)	
Native Hawaiian/Pacific Islander	2	0 (0.0)	-0.03 (-0.06, -0.01)		1 (50.0)	0.35 (-0.35, 1.05)	
Trans Women							
White	205	15 (7.3)	-0.07 (-0.46, 0.32)		42 (20.5)	-0.06 (-0.50, 0.38)	
Asian	32	9 (28.1)	**0.25 (0.09, 0.40)**	0.44 (-0.16, 1.05)	11 (34.4)	0.18 (0.00, 0.35)	0.14 (-0.55, 0.83)
Black	25	4 (16.0)	0.13 (-0.02, 0.27)	0.33 (-0.75, 1.41)	12 (48.0)	**0.31 (0.11, 0.51)**	**0.64 (0.22, 1.07)**
Latinx	41	17 (41.5)	**0.38 (0.23, 0.54)**	**0.74 (0.47, 1.02)**	12 (29.3)	0.13 (-0.02, 0.28)	0.19 (-0.46, 0.85)
Native American/Alaska Native	14	6 (42.9)	**0.39 (0.13, 0.65)**	**0.77 (0.37, 1.17)**	4 (28.6)	0.11 (-0.14, 0.35)	0.02 (-1.21, 1.26)
Native Hawaiian/Pacific Islander	44	15 (34.1)	**0.31 (0.16, 0.45)**	**0.93 (0.81, 1.05)**	21 (47.7)	**0.32 (0.17, 0.48)**	-0.11 (-1.65, 1.42)
Non-binary AMAB							
White	128	12 (9.4)	-0.27 (-0.62, 0.07)		35 (27.3)	-0.19 (-0.68, 0.30)	
Asian	16	0 (0.0)	-0.03 (-0.06, -0.01)	NA	1 (6.2)	-0.09 (-0.22, 0.04)	-4.83 (-18.38, 8.72)
Black	7	1 (14.3)	0.11 (-0.15, 0.37)	0.07 (-2.30, 2.45)	3 (42.9)	0.27 (-0.11, 0.65)	0.46 (-0.29, 1.20)
Latinx	33	4 (12.1)	0.09 (-0.03, 0.20)	-0.03 (-1.63, 1.58)	8 (24.2)	0.07 (-0.08, 0.23)	-0.31 (-1.56, 0.94)
Native American/Alaska Native	12	1 (8.3)	0.05 (-0.11, 0.21)	-0.72 (-6.44, 4.99)	7 (58.3)	**0.42 (0.13, 0.71)**	0.45 (-0.18, 1.08)
Native Hawaiian/Pacific Islander	7	0 (0.0)	-0.03 (-0.06, -0.01)	NA	0 (0.0)	-0.15 (-0.20, -0.10)	NA
Non-binary AFAB							
White	587	33 (5.6)	-0.16 (-0.52, 0.21)		130 (22.1)	-0.15 (-0.57, 0.27)	
Asian	61	4 (6.6)	0.03 (-0.04, 0.09)	-1.38 (-4.57, 1.81)	9 (14.8)	-0.03 (-0.14, 0.07)	-1.40 (-3.67, 0.86)
Black	25	0 (0.0)	**-0.04 (-0.06, -0.01)**	NA	6 (24.0)	0.05 (-0.13, 0.23)	0.13 (-0.98, 1.24)
Latinx	48	6 (12.5)	0.09 (-0.01, 0.19)	0.23 (-0.68, 1.13)	15 (31.2)	0.14 (0.00, 0.28)	0.18 (-0.44, 0.80)
Native American/Alaska Native	44	5 (11.4)	0.08 (-0.02, 0.18)	0.13 (-1.51, 1.76)	10 (22.7)	0.05 (-0.08, 0.19)	-0.30 (-1.74, 1.14)
Native Hawaiian/Pacific Islander	11	0 (0.0)	**-0.04 (-0.06, -0.01)**	NA	1 (9.1)	-0.09 (-0.26, 0.08)	-5.89 (-22.74, 10.96)

AFAB, assigned female at birth; AMAB, assigned male at birth; AR, attributable risk; CI, confidence interval; RD, risk difference.
This table excludes data collected from the Public Health-Seattle & King County Sexual Health Clinic, which did not collect data on medical insurance and access to a regular doctor/provider. Measures of RD and AP are adjusted for participant age. The null value for the RD and AP is 0 and the reference for group is White transgender men. Bolded numbers indicate statistically significant results in which 95% CI's that don't contain the null. NAs indicate division by zero.

Table 2.3. Intersectionality Analysis for HIV/STI Positivity and Past Year HIV/STI Testing among Transgender and Non-binary People in Washington State, 2019-2021

	HIV/STI Positivity[1]				Past Year HIV/STI Testing[2,3]			
	N	n (%)	RD (95% CI)	AP (95% CI)	N	n (%)	RD (95% CI)	AP (95% CI)
Overall	1648	135 (8.2)			1006	517 (51.4)		
Trans Men								
White [ref]	267	11 (4.1)	ref		168	74 (44)	ref	
Asian	23	1 (4.3)	-0.01 (-0.09, 0.08)		11	6 (54.5)	0.06 (-0.24, 0.36)	
Black	20	4 (20.0)	0.16 (-0.02, 0.34)		8	6 (75.0)	**0.33 (0.03, 0.63)**	
Latinx	29	2 (6.9)	0.03 (-0.07, 0.13)		18	7 (38.9)	-0.09 (-0.33, 0.15)	
Native American/Alaska Native	13	0 (0.0)	**-0.04 (-0.07, -0.02)**		8	4 (50.0)	0.09 (-0.27, 0.45)	
Native Hawaiian/Pacific Islander	2	0 (0.0)	**-0.03 (-0.06, -0.01)**		1	0 (0.0)	-0.38 (-0.46, -0.30)	
Trans Women								
White	240	20 (8.3)	0.02 (0.00, 0.03)		136	85 (62.5)	0.46 (-0.10, 1.02)	
Asian	37	2 (5.4)	0.02 (-0.06, 0.10)	-0.51 (-3.05, 2.03)	25	18 (72.0)	**0.31 (0.11, 0.51)**	0.05 (-0.41, 0.51)
Black	32	15 (46.9)	**0.43 (0.25, 0.60)**	**0.50 (0.07, 0.93)**	23	18 (78.3)	**0.36 (0.19, 0.54)**	-0.22 (-0.69, 0.25)
Latinx	53	13 (24.5)	**0.21 (0.10, 0.33)**	**0.67 (0.27, 1.08)**	34	30 (88.2)	**0.46 (0.32, 0.60)**	**0.41 (0.13, 0.69)**
Native American/Alaska Native	16	3 (18.8)	0.14 (-0.05, 0.34)	**0.79 (0.46, 1.12)**	11	9 (81.8)	**0.37 (0.12, 0.62)**	0.08 (-0.47, 0.63)
Native Hawaiian/Pacific Islander	47	11 (23.4)	**0.20 (0.08, 0.32)**	**0.85 (0.67, 1.03)**	39	28 (71.8)	**0.33 (0.16, 0.49)**	**0.74 (0.58, 0.89)**
Non-binary AMAB								
White	183	39 (21.3)	**0.46 (0.14, 0.79)**		95	62 (65.3)	0.37 (-0.29, 1.04)	
Asian	22	7 (31.8)	**0.29 (0.09, 0.48)**	0.36 (-0.35, 1.07)	10	6 (60.0)	0.22 (-0.09, 0.54)	-0.13 (-0.88, 0.62)
Black	13	4 (30.8)	**0.27 (0.02, 0.52)**	-0.18 (-2.68, 2.31)	6	6 (100.0)	**0.60 (0.51, 0.69)**	0.04 (-0.31, 0.39)
Latinx	43	14 (32.6)	**0.29 (0.15, 0.43)**	0.29 (-0.83, 1.40)	26	18 (69.2)	**0.25 (0.07, 0.44)**	0.14 (-0.29, 0.57)
Native American/Alaska Native	13	1 (7.7)	0.04 (-0.11, 0.19)	-1.25 (-3.92, 1.43)	8	7 (87.5)	**0.46 (0.22, 0.70)**	0.15 (-0.35, 0.66)
Native Hawaiian/Pacific Islander	7	1 (14.3)	0.11 (-0.15, 0.37)	-0.12 (-1.44, 1.21)	5	3 (60.0)	0.22 (-0.22, 0.66)	**0.63 (0.34, 0.91)**
Non-binary AFAB								
White	623	10 (1.6)	0.01 (0.00, 0.02)		401	169 (42.1)	0.03 (-0.54, 0.60)	
Asian	61	3 (4.9)	0.01 (-0.05, 0.07)	**0.74 (0.29, 1.19)**	40	22 (55.0)	0.12 (-0.05, 0.29)	0.12 (-0.30, 0.53)
Black	30	3 (10.0)	0.05 (-0.05, 0.16)	-0.79 (-1.43, -0.15)	20	13 (65.0)	0.21 (-0.01, 0.43)	-0.20 (-0.68, 0.27)
Latinx	52	2 (3.8)	0.00 (-0.05, 0.06)	-0.12 (-1.22, 0.98)	32	12 (37.5)	-0.07 (-0.25, 0.11)	0.03 (-0.59, 0.66)
Native American/Alaska Native	46	3 (6.5)	0.02 (-0.05, 0.10)	**1.43 (1.27, 1.58)**	32	12 (37.5)	-0.05 (-0.23, 0.12)	-0.41 (-1.31, 0.49)
Native Hawaiian/Pacific Islander	11	2 (18.2)	0.14 (-0.08, 0.37)	**1.14 (1.08, 1.21)**	9	4 (44.4)	-0.01 (-0.32, 0.30)	**1.00 (0.72, 1.27)**

AFAB, assigned female at birth; AMAB, assigned male at birth; AR, attributable risk; CI, confidence interval; RD, risk difference; PrEP, preexposure prophylaxis; STI, sexually transmitted infection. Measures of RD and AP are adjusted for participant age. The null value for the RD and AP is 0 and the reference for group is White transgender men. Bolded numbers indicate statistically significant results in which 95% CI's that don't contain the null.

[1] Defined as participants who self-reported having a bacterial STI (e.g. chlamydia, gonorrhea, syphilis) in the last 12 months or who self-reported being HIV positive.

[2] Excludes data collected from the Public Health-Seattle & King County Sexual Health Clinic, which did not collect data on STI testing.

[3] Restricted to sexually active participants who reported any oral, vaginal/front hole, or anal sex in the past 12 month.

Table 2.4. Intersectionality Analysis for PrEP Access among Transgender and Non-binary People in Washington State, 2019-2021

	Ever Discussed PrEP with a Provider[1,2]				**Current PrEP Use[1]**			
	N	n (%)	RD (95% CI)	AP (95% CI)	N	n (%)	RD (95% CI)	AP (95% CI)
Overall	948	203 (21.4)			1085	90 (8.3)		
Trans Men								
White [ref]	164	33 (20.1)	ref		175	7 (4.0)	ref	
Asian	9	5 (55.6)	**0.37 (0.04, 0.71)**		11	1 (9.1)	0.05 (-0.12, 0.23)	
Black	9	3 (33.3)	0.13 (-0.18, 0.45)		16	3 (18.8)	0.14 (-0.05, 0.34)	
Latinx	19	1 (5.3)	**-0.16 (-0.28, -0.04)**		20	1 (5.0)	0.02 (-0.08, 0.12)	
Native American/Alaska Native	10	3 (30.0)	0.10 (-0.19, 0.39)		11	0 (0.0)	**-0.04 (-0.07, -0.01)**	
Native Hawaiian/Pacific Islander	1	0 (0.0)	**-0.19 (-0.26, -0.13)**		1	0 (0.0)	**-0.05 (-0.08, -0.01)**	
Trans Women								
White	132	37 (28.0)	0.46 (-0.10, 1.02)		148	16 (10.8)	0.46 (-0.10, 1.02)	
Asian	24	8 (33.3)	0.16 (-0.04, 0.36)	-0.95 (-2.45, 0.55)	28	6 (21.4)	**0.17 (0.02, 0.33)**	0.21 (-0.86, 1.27)
Black	21	9 (42.9)	**0.23 (0.01, 0.45)**	0.03 (-0.87, 0.94)	21	6 (28.6)	**0.24 (0.05, 0.44)**	0.15 (-0.75, 1.04)
Latinx	32	12 (37.5)	0.17 (-0.01, 0.35)	**0.66 (0.25, 1.06)**	34	9 (26.5)	**0.23 (0.07, 0.38)**	**0.58 (0.07, 1.09)**
Native American/Alaska Native	9	5 (55.6)	**0.36 (0.02, 0.69)**	0.29 (-0.40, 0.98)	11	5 (45.5)	**0.42 (0.12, 0.72)**	**0.89 (0.75, 1.03)**
Native Hawaiian/Pacific Islander	35	16 (45.7)	**0.26 (0.08, 0.44)**	**0.83 (0.61, 1.05)**	34	5 (14.7)	0.10 (-0.02, 0.23)	0.52 (-0.06, 1.09)
Non-binary AMAB								
White	82	36 (43.9)	0.37 (-0.29, 1.04)		127	25 (19.7)	0.37 (-0.29, 1.04)	
Asian	8	2 (25.0)	0.08 (-0.23, 0.39)	-2.16 (-7.46, 3.13)	10	0 (0.0)	**-0.05 (-0.08, -0.01)**	NA
Black	6	4 (66.7)	**0.47 (0.09, 0.85)**	0.14 (-0.83, 1.11)	9	2 (22.2)	0.18 (-0.09, 0.45)	-0.53 (-3.69, 2.63)
Latinx	25	12 (48.0)	**0.27 (0.07, 0.48)**	0.42 (-0.02, 0.87)	35	14 (40.0)	**0.36 (0.20, 0.53)**	**0.58 (0.09, 1.08)**
Native American/Alaska Native	9	5 (55.6)	**0.36 (0.03, 0.69)**	0.02 (-1.04, 1.08)	9	3 (33.3)	0.29 (-0.02, 0.60)	**0.54 (0.14, 0.94)**
Native Hawaiian/Pacific Islander	5	0 (0.0)	-0.19 (-0.26, -0.13)	NA	5	0 (0.0)	-0.05 (-0.08, -0.01)	NA
Non-binary AFAB								
White	376	38 (10.1)	0.03 (-0.54, 0.60)		404	6 (1.5)	0.03 (-0.54, 0.60)	
Asian	38	4 (10.5)	-0.07 (-0.19, 0.04)	-3.37 (-5.70, -1.04)	38	0 (0.0)	**-0.04 (-0.07, -0.01)**	NA
Black	19	5 (26.3)	0.06 (-0.14, 0.27)	0.12 (-0.48, 0.72)	22	2 (9.1)	0.05 (-0.07, 0.18)	**-0.68 (-1.25, -0.10)**
Latinx	30	5 (16.7)	-0.04 (-0.19, 0.11)	1.35 (1.01, 1.70)	33	1 (3.0)	-0.01 (-0.07, 0.06)	-0.01 (-1.35, 1.33)
Native American/Alaska Native	31	5 (16.1)	-0.03 (-0.18, 0.11)	-0.25 (-1.21, 0.71)	33	2 (6.1)	0.02 (-0.07, 0.11)	**1.53 (1.35, 1.70)**
Native Hawaiian/Pacific Islander	9	1 (11.1)	-0.09 (-0.30, 0.12)	1.90 (1.34, 2.46)	9	0 (0.0)	**-0.04 (-0.07, -0.01)**	NA

AFAB, assigned female at birth; AMAB, assigned male at birth; AR, attributable risk; CI, confidence interval; RD, risk difference; PrEP, preexposure prophylaxis; STI, sexually transmitted infection. Measures of RD and AP are adjusted for participant age. The null value for the RD and AP is 0 and the reference for group is White transgender men. Bolded numbers indicate statistically significant results in which 95% CI's that don't contain the null. NAs indicate division by zero.

[1] Restricted to participants who reported any vaginal/front hole or anal sex in the past 12 month.

[2] Excludes data collected from the Public Health-Seattle & King County Sexual Health Clinic, which did not collect these data.

Chapter 3: Heterogeneity in HIV/STI Prevalence and Prevention Among the Partners of Transgender and Non-binary People

ABSTRACT

Background: Transgender and non-binary (TNB) people are diverse in sexual orientation and their choice of sexual and romantic partnerships. We described the epidemiology of HIV/STIs and prevention utilization among the partners of TNB people.

Methods: We pooled data from five 2017-2021 cross-sectional data sources in Washington State to generate a large sample of TNB people and cisgender partners of TNB people. We describe characteristics of recent partners of trans women, trans men, and non-binary people and used Poisson regression to assess if having a recent TNB partner is associated with prevalent HIV/STI, testing, and PrEP use.

Results: Our study included 360 trans women, 316 trans men, 963 non-binary people, 2896 cis women, and 7540 cis men. Overall, 9% of sexual minority cis men and 13% of sexual minority cis women reported having any TNB partners. TNB people were diverse in their sexual partnerships and 36% reported having a partner who was also TNB. There was significant heterogeneity in HIV/STI prevalence, testing and PrEP use among the partners of TNB people by study participant gender and gender of their sex partners. In regression models, having a TNB partner was associated with a 2-fold higher likelihood of HIV/STI testing but was not associated with higher HIV prevalence.

Conclusion: Our study findings suggest there is significant heterogeneity in HIV/STI prevalence and preventative behaviors among the partners of TNB people. Given that TNB people are diverse in their sexual and romantic partnerships, there is a need to better understand individual-, dyad-, and structural-level factors that facilitate HIV/STI prevention across these diverse partnerships.

INTRODUCTION

Transgender and non-binary (TNB) people are diverse in sexual orientation and their choice of sexual and romantic partnerships. Data from the 2015 US Transgender Survey show that 69% of trans women, 70% of trans men, and 81% of non-binary people identify as gay, bisexual, pansexual, or queer.[3] There are several small studies that provide data on the genders of TNB people's partners, but these studies vary greatly in their estimates.[4,12,29,112–118] In addition, these studies have been mostly conducted among trans men and non-binary people assigned female at birth (AFAB), and infrequently include non-binary people as a partner option. The scarcity of studies that report on the diversity of trans women's partnerships may reflect assumptions that trans women only partner with cisgender (cis) men, or it may be a byproduct of HIV study inclusion criteria which limit enrollment to participants that report sex with people assigned male at birth (AMAB).[23,119]

In addition, little is known about the cisgender sex partners of TNB people. The HIV/STI prevalence and uptake of preventative behaviors by the partners of TNB people play an important role in TNB people's sexual health. To date, most of the literature on the partners of TNB people has focused on cis men who have sex with trans women.[120] Overall, these men report high levels of stigma and syndemic factors (e.g., substance use, poverty) and low levels of HIV/STI prevention behaviors.[120] Another subset of studies focuses on cisgender men who have sex with men (MSM) who report having any transgender partners (e.g., any partners who are trans women, trans men, or non-binary people).[121,122] These studies have found that cis MSM with any TNB partners are more likely to report injection drug use, 5 or more partners in the past 6 months, transactional sex, and condomless anal sex. However, a significant limitation of these studies is that they assume that HIV/STI behavioral factors are similar among cis MSM who partner with trans people, regardless of the gender identity of their trans partners. In reality, there are likely important differences in social and sexual identity and relationship stigma between, for example, cis men who partner with trans women compared to cis men who partner with trans men, that may in turn impact sexual practices and access to HIV/STI prevention.[123,124] There is evidence to suggest that trans women and trans men who have sex with cis men are more likely to acquire HIV [12,14,125–128] and STIs [129,130] compared to those who do not have sex with cis men. However, there has been little investigation of the HIV/STI prevalence and prevention behaviors among TNB people who partner with other TNB people and with cis women.[128] These gaps in the literature have led to limited understanding of HIV/STI prevalence and prevention behaviors among the heterogeneous populations of TNB people and their partners.

Therefore, the overall aim of the present study was to describe the epidemiology of HIV/STI prevalence and identify disparities in HIV/STI testing and pre-exposure prophylaxis (PrEP) use for the partners of TNB people. In this study, we pooled multiple data sources from Washington state (WA) to generate a large sample of TNB people and cisgender partners of TNB people. First, we estimate the proportion of participants (both cis and TNB) who had a TNB partner in the last year. Second, we describe characteristics of recent partners of trans women, trans men, and non-binary people. Third, we assess if having a recent TNB partner is associated with prevalent HIV/STI, testing, and PrEP use.

METHODS

Data sources and study population

We pooled cross-sectional data from five data sources available through Public Health – Seattle & King County (PHSKC): all five included TNB participants and cis men, and three included cis women. Details on each data source are available in Appendix C.

PHSKC Pride Surveys. We utilized three years of data (2019, 2020, and 2021) from PHSKC's Pride Survey, an annual survey conducted for surveillance purposes through PHSKC's HIV/STD Program. The 2019 Pride Survey was conducted in person during two Pride Events: the Trans Pride festival held at Cal Anderson Park in the Capitol Hill neighborhood of Seattle and the Seattle Pride Parade held in downtown Seattle. Participants were eligible if they lived in WA and identified as trans or non-binary and/or as a gay, bisexual or other MSM. Participants in the 2019 Pride Survey completed an anonymous paper survey and were given a small incentive (a package with condoms, lubes, and a $5 coffee gift card) after completing the survey. Due to the COVID-19 pandemic, the 2020 and 2021 Pride Surveys were conducted online through an anonymous RedCap survey. The inclusion criteria for the 2020 and 2021 Pride Surveys were expanded to include anyone who lived in WA and self-identified as LGBTQ+. The majority of Pride Survey participants lived in Seattle and King County, WA.

National HIV Behavioral Surveillance (NHBS). The NHBS survey is coordinated by the Centers for Disease Control and Prevention (CDC) across 22 cities, including Seattle, and collects data on behavioral factors for HIV transmission, HIV testing, and the use of prevention strategies. Surveillance is conducted annually and rotates through different populations with high HIV incidence. We utilized de-identified Seattle site data from the 2017 NHBS cycle conducted among cis MSM and the 2019 NHBS cycle conducted among trans women and non-binary people assigned male at birth (AMAB), locally called *Project First*. The cycle among cis MSM used venue-based sampling, while the cycle among trans women recruited participants using respondent-driven sampling. Data for both NHBS surveys were collected via an in-person interview.

PHSKC Sexual Health Clinic. The PHSKC Sexual Health Clinic in Seattle provides walk-in STI/HIV testing and treatment on a sliding fee basis. All new patients complete a computer-assisted self-interview (CASI), which includes information on demographics, HIV/STI history, and sexual behaviors. We utilized de-identified CASI data from patients who attended the Sexual Health Clinic between December 2018 and February 2020. We restricted our analysis to a patient's first visit during the study period.

The secondary analysis of these pooled data were conducted in collaboration with the Seattle Trans and Non-binary Sexual Health (STARS) Advisory Board, a community advisory group of 9 transgender and non-binary people from the Seattle area that met bimonthly between February 2021 and July 2022. Ethical approval was received from the University of Washington Institutional Review Board.

Measures

The above data sources all used identical or similar questions to ascertain the following measures.

Gender identity. All data sources used a validated trans-inclusive two-step question for ascertaining gender identity, which asks two distinct questions about current gender and sex assigned at birth. All surveys provided non-binary/genderqueer and write-in response options.

Sexual minority status: We defined sexual minority participants as anyone who self-identified as gay, lesbian, bisexual, pansexual, or queer. PHSKC Pride Survey participants were able select more than one sexual orientation, so, percentages for specific identities may sum to greater than 100%.

Gender of sex partners. Most data sources asked participants about the gender of the sex partners they had in the last year using questions that included cis men, cis women, trans women, trans men, and non-binary people as potential response options. Sex was defined as any oral, vaginal or anal sex. Information about the sex assigned at birth of non-binary partners was only collected at the Sexual Health Clinic, the 2020 Pride Survey, and the 2021 Pride Survey. The NHBS cycle among trans women only assessed the gender of a participant's last three sex partners and did not provide a non-binary response option.

HIV/STI related measures. Self-reported HIV/STI related measures included self-reported HIV testing (ever and in the last year), STI testing in the last year, HIV status, and history of any bacterial STIs (i.e., chlamydia, gonorrhea, and syphilis) in the last year. Among self-reported HIV-negative participants, PrEP questions included awareness of PrEP, ever discussing PrEP with a provider, current and ever PrEP use, and reasons for not using PrEP. The Sexual Health Clinic did not ascertain STI testing behaviors in the last year, awareness of PrEP, if a person has ever discussed PrEP with a provider, or reasons for not using PrEP. Among people living with HIV, we included self-reported current antiretroviral therapy (ART) use and viral suppression (i.e., if last viral load was undetectable); these variables were not collected in the Pride Surveys.

Socio-structural factors. The Pride and NHBS Surveys asked questions about annual income, experiences of homelessness/unstable housing in the last year, and health care insurance. The Sexual Health Clinic did not collect data on any of the socio-structural variables.

Statistical analyses

Using the pooled data, we estimated the proportion of participants who had a TNB partner in the last year, stratified by participants' gender identity and sexual minority status. Among cisgender participants who had a TNB partner in the last year, we report descriptive statistics for the participants' sexual orientation, the gender of their sex partners, HIV/STI related measures, and socio-structural factors.

We then used regression analysis to assess if HIV/STI prevalence, testing, or PrEP use was associated with having a trans or non-binary partner in the past year. In order to account for heterogeneity within the trans and non-binary population, we estimated separate regression models with the following binary dependent variables: (i) having any trans women sex partners in the past year, (ii) having any trans men sex partners in the past year, and (iii) having any non-binary sex partners in the past year. Analyses were stratified and conducted separately for cis men, cis women, and all trans and non-binary participants. We checked for effect modification by gender identity in our models conducted among all trans and non-binary participants by fitting an interaction term with a categorical variable for gender identity. These sensitivity analyses tested if there was heterogeneity in factors associated with having a trans partner between trans women, trans men, nonbinary people AMAB, and non-binary people AFAB. We used bivariate Poisson regression models with robust standard errors to estimate prevalence ratios and 95% confidence intervals, adjusted for the data source and year. Additional correlates of having a recent TNB partner are reported in Appendix C. All analyses were conducted in R statistical software.

RESULTS

The pooled sample included 12,084 participants: 360 trans women, 316 trans men, 963 non-binary people, 2896 cis women, and 7540 cis men. Sexual minority TNB people were diverse in their sexual identity and partnerships (Table 3.1), and many reported having other TNB partners in the last year (36% of trans men, 44% of trans women, 46% of non-binary people AMAB, and 39% of non-binary people AFAB). In addition, 9% of sexual minority cis men and 13% of sexual minority cis women reported having any TNB partners in the last year. Only 2% of heterosexual cis men reported having a TNB partner, most commonly trans women, and only one heterosexual cis woman reported having a non-binary partner AMAB.

TNB Participants' Self-Reported Partnerships

Many trans women (76%) had a sexual minority identity: 26% identified as queer, 25% as lesbian, 22% as bisexual, 16% as pansexual, and 9% as gay (Table 3.1). Sexual minority trans women most frequently partnered with cis men (40%) and many also partnered with other women (27% with trans women and 23% with cis women) and non-binary people (25%); 11% of trans women partnered with trans men. A quarter of trans women identified as heterosexual; these women primarily reported cis men partners (80%).

Nearly all trans men (95%) had a sexual minority identity: 50% identified as queer, 29% as bisexual, 25% as gay, and 15% as pansexual (Table 3.1). Sexual minority trans men most frequently partnered with other men (34% with cis men and 20% with trans men), cis women (28%), and non-binary people (23%). Only 5% of trans men identified as heterosexual, and these men reported having cis women or cis men partners.

Nearly all non-binary people (>99%) had a sexual minority identity. Among non-binary people AMAB, 53% identified as queer, 32% as gay, 20% as pansexual, 16% as bisexual, and 4% as lesbian (Table 3.1). Among non-binary people AFAB, 60% identified as queer, 28% as pansexual, 23% as bisexual, 15% as lesbian, and 8% as gay. Only 5 (<1%) non-binary participants identified as heterosexual. Non-binary people AMAB most frequently partnered with cis men (61%), other non-binary people (44%), and cis women (21%). Similarly, non-binary people AFAB most commonly partnered with cis men (35%), other non-binary people (33%), and cis women (26%).

Detailed data on the gender of TNB people's sex partners stratified by specific sexual orientations and gender identity are reported in Appendix C (Supplemental Tables 3.3-3.6).

Participants Who Reported Having Trans Women Partners

There were 131 cis men and 49 cis women in our sample who reported having a trans woman partner in the last year (1% of heterosexual cis men, 2% of sexual minority cis men, and 3% of sexual minority cis women; Table 3.1). In our sample, cis men with trans women partners most commonly identified as bisexual (47%) and cis women with trans women partners most commonly identified as queer (49%, Table 3.2). There also were 212 TNB people who reported having a trans woman partner in the last year (11% of non-binary people AFAB, 12% of non-binary people AMAB, 8% of trans men, 21% of trans women). Among these TNB participants, non-binary people and trans men mostly identified as queer, bisexual and pansexual while trans women with other trans woman partners most commonly identified as lesbian, queer or pansexual (Table 3.2). Exclusive partnering with trans women was reported most commonly by cis women (28%), trans women (21%), and non-binary people AFAB (23%), compared to just 5% of cis men.

Participants Who Reported Having Trans Men Partners

There were 216 cis men and 63 cis women in our sample who reported having a trans man partner in the last year (0.6% of heterosexual cis men, 4% of sexual minority cis men, and 3% of sexual minority cis women; Table 3.1). Cis men with trans men partners most commonly identified as gay (50%, Table 3.3) and 90% also reported partnering with cis men. The majority of cis women who reported having a trans man partner in the last year identified as queer (64%, Table 3.3). There also were 187 TNB people who reported having a trans man partner in the last year (10% of non-binary people, 19% of trans men, 9% of trans women). Most of these TNB participants identified as queer, although 30% of trans men with other trans men partners identified as gay (Table 3.3). Exclusive partnering with trans men was reported most commonly by cis women and trans men (40% and 35%, respectively, compared to no non-binary people AMAB and just 2% of cis men).

Participants Who Reported Having Non-binary Partners

Among cisgender participants, having a non-binary partner was much more common than having a trans partner with a binary identity (i.e., trans women or trans men). There were 292 cis men and 175 cis women in our sample who reported having a non-binary partner in the last year (0.7% of heterosexual cis men, 6% of sexual minority cis men, and 9% of sexual minority cis women**;** Table 3.1). Cis men with non-binary partners most commonly identified as gay (53%) and cis women with non-binary partners most commonly identified as queer (46%, Table 3.4). There also were 462 TNB people who reported having a non-binary partner in the last year (35% of non-binary people, 22% of trans men, 15% of trans women), most of whom identified as queer. Cis women and non-binary people AFAB were most likely to report exclusively having non-binary partners (27% and 29%, respectively), compared to 5% of cis men and 6% of non-binary people AMAB.

Self-reported HIV/STI Positivity

Self-reported HIV positivity was highest among cis men who partner with non-binary people (14%) and cis men who partner with trans men (13%). In addition, 9% of non-binary people AMAB who partner with trans men and 5% of cis men who partner with trans women were HIV positive. However, having a TNB partner was not associated with a higher HIV prevalence in any regression models, which adjusted for data source, age, race, and ethnicity (Tables 3.5-3.7). Among participants living with HIV for whom we had data on ART use and viral suppression, 88% were currently on HIV medications and virally suppressed.

Self-reported history of having any bacterial STI within the last year was highest among cis men who partner with trans men (43%), with non-binary people (32%), and with trans women (30%). Self-reported STI positivity was also high among non-binary people AMAB who partner with trans men (47%), with trans women (41%), and with other non-binary people (40%). Overall, only 4% of trans women, 8% of non-binary people AFAB, 11% of cis women, and 15% of trans men with any TNB partners reported having a bacterial STI within the last year. In most regression models, having a TNB partner was not associated with a higher likelihood of having had a bacterial STI in the past year compared to participants without a TNB partner. However, cis men who partner with trans men (aPR 2.42, 95%CI: 1.81-3.26, Table 3.6) and with non-binary people (aPR 1.66, 95%CI: 1.26-2.20, Table 3.7) had a higher likelihood of having had a bacterial STI in the past year, compared to cis men without TNB partners.

HIV/STI Testing

Ever testing for HIV was high among all participants who reported having TNB partners (>65%) and was highest among cis men and non-binary people AMAB with TNB partners (>90%). Past year HIV testing varied between 46-69% for all participants who reported having a TNB partner, except only a third of cis women with TNB partners tested for HIV in the last year. Similar patterns were observed for STI testing in the last year. In all regression models, having a TNB partner was associated with a 2-fold increased likelihood of HIV testing compared to participants without a TNB partner (Tables 3.5-3.7). Among cis men and TNB participants, regression models suggest that having a TNB partner is also associated with higher likelihood of STI testing in the last year.

PrEP Awareness/Use

Most participants who reported having a TNB partner had previously heard of PrEP (Table 3.2-3.4). PrEP use was highest among cis men who partner with trans men (50% ever, 35% current) and with non-binary people (43% ever, 29% current). PrEP use was also high among non-binary people who partner with trans men (40% ever, 29% current) and with other non-binary people (45% ever, 27% current). In regression analyses, cis men who partner with trans men and non-binary people were also more likely to currently use PrEP compared to cis men in the sample without a TNB partner (aPR 1.98, 95%CI:1.47-2.67; and, aPR 1.60, 95%CI: 1.22-2.10; Tables 3.6-3.7). Cis men who partner with trans women were significantly less likely to have ever used PrEP (aPR 0.34, 95%CI: 0.22-0.53, Table 3.5) compared to other cis men in the sample. Notably, only 5% of cis women who reported having a TNB partner had ever discussed PrEP with a provider and only 3% had ever used PrEP. Among TNB participants, PrEP awareness, discussing PrEP with a provider, ever and current PrEP use were all significantly and positively associated with partnering with other TNB people in the last year in regression models.

Socio-structural Factors

Cisgender and TNB people who reported partnerships with a trans woman or trans man in the last year were more likely to be unstably housed or homeless (Supplemental Table 3.7 and 3.8). Cis men who partnered with trans women more frequently lacked health insurance (18%; aPR 0.46, 95% CI 0.21, 0.99; Supplemental Table 3.7) compared to cis men who did not partner with trans women. In addition, TNB people who reported partnering with trans women were more likely to have annual incomes below $15,000 (52% of trans men and 41% of trans women, Table 3.2; aPR 1.77, 95% CI 1.16, 2.70; Supplemental Table 3.7) compared to TNB people who did not partner with trans women.

DISCUSSION

In this study, the majority of TNB participants identified as sexual minorities and were diverse in their partnerships. Notably, nearly half of TNB people reported having trans-trans partnerships, which were positively associated with HIV/STI testing and PrEP awareness/use. Among the cisgender study participants with TNB partners, we observed significant heterogeneity in self-reported HIV positivity and history of STIs as well as HIV/STI testing behaviors and PrEP use. Overall, cis men who partner with trans men and non-binary people had the highest self-reported HIV prevalence and history of STIs, although these men were also the most likely to engage in high levels of testing and current PrEP use. In contrast, cis men who partner with trans women were least likely to access PrEP or recent HIV/STI testing. Overall, cis women with TNB partners reported very low rates of HIV/STI testing and indicated significant missed opportunities to discuss PrEP with their healthcare providers.

Previous studies have found that 1% to 4% of cisgender people report having TNB partners.[29,121,123,131] However, in our study, stratifying by sexual minority status revealed that 9% of sexual minority cis men and 13% of sexual minority cis women had a TNB partner in the last year. A much smaller proportion of heterosexual cis men and women (<1.0%) reported recent partnerships with TNB people. Despite the diversity of partnerships among TNB people, most literature on the partners of TNB people has focused on cis men who partner with trans women. In our sample, we observed that while 80% of heterosexual trans women partner with cis men, only 40% of sexual minority trans women do. In fact, many sexual minority trans women partner with other trans women, non-binary people, and cis women. Several US-based studies have similarly found that many (21% to 55%) TNB people report having partners who are also TNB.[12,29,112–114]

Our findings related to cis men who partner with trans women align with prior studies. Existing literature on cis men with partners who are trans women identify numerous intersectional and syndemic factors, including poverty, unstable housing, incarceration, substance use, and poor mental health.[120,122] In our study, we also observed that cis men with trans women partners most frequently reported socio-structural barriers including unstable housing and lack of health insurance. However, the HIV prevalence among cis men who partner with trans women in our study was significantly lower (5%) than a recent meta-analysis estimate (30.6%; 95% CI: 18.1-

43.0%).[31] This may reflect geographic differences in study populations, since the majority of the studies included in the meta-analysis were conducted in San Francisco and Los Angeles.

Our study also adds to a small but growing body of research on trans men and their cis man partners. We observed that cis men who partner with trans men had high self-reported HIV/STI prevalence, but also engaged in the highest level of HIV/STI prevention activities (e.g., recent testing and PrEP use). It was unsurprising that nearly all cis men in our sample who partnered with trans men also reported sex with cis men and identified as gay, bi- or pansexual, and queer. Similar to these findings, a study of trans men in San Francisco found that 83% of their cis man partners also reported sex with a cis man in the past 6 months.[112] In contrast, only one prior study has examined HIV/STI-related behaviors among cis women who partner with TNB people. That study, which analyzed data from the Melbourne sexual health clinic, similarly observed that cis women who reported any TNB sexual partner were more likely to report injection drug use and sex work, and were significantly more likely to identify as lesbian or bisexual than heterosexual.[131]

Our study leveraged data sources that were designed for HIV/STI surveillance purposes, and therefore, most of these surveys did not assess specific constructs related to relationship stigma, dyad-level characteristics, or socio-structural barriers to care. Although we were unable to assess stigma in our study, it is important for contextualizing our findings. Stigma and minority stress are key structural factors that disproportionately create the contexts (e.g., sex work, unequal power in relationships) and behaviors (e.g., substance use during sex, decreased condom use) that increase TNB people's vulnerability to HIV/STI acquisition.[81,132–135] Among TNB people, experiences of stigma from cisgender sexual partners are negatively associated with HIV/STI prevention. For example, a study conducted among trans men who have sex with cis men found that higher levels of enacted anti-transgender stigma from partners during sexual encounters was associated with lower odds of HIV testing and higher odds of condomless receptive sex in the last 6 months.[136] Cisgender partners of TNB people may also experience anti-transgender stigma from friends and family due to their relationships with TNB people.[31,120,137] Importantly, anti-transgender stigma may have a differential impact on cis men with trans women partners based on their sexual orientation. For example, a recent study found that stigma had different associations with HIV-related behaviors (e.g., increased likelihood of condomless sex or recent STI diagnosis) for gay-identified compared to heterosexually-identified cis men in primary partnerships with trans women.[124]

In contrast, minority group identification can facilitate a sense of in-group community that can be protective.[137,138] In supportive partnerships, increased communication related to sex can be gender-affirming [139] and can facilitate HIV/STI prevention (through clear sexual agreements, negotiating condom use, talking about HIV/STI status and testing, etc). This may be especially true of trans people who partner with other trans or non-binary individuals, since trans people in relationships with trans partners report higher levels of support compared to those in relationships with cisgender people.[140] Our study found that TNB people with trans partners were more likely to engage in HIV/STI testing and PrEP use compared to TNB people who only had cisgender partners. Members of the community advisory board reflected that these findings align with what they observed within their community – that trans people support one another, which includes HIV/STI prevention and care. However, the literature on trans-trans relationships is sparse and this topic warrants further research, especially given that nearly half of all TNB participants reported having TNB sex partners.

Our study should be interpreted in light of the following limitations. First, our data come from convenience samples, including one clinical sample, which likely bias our sample in the following ways. All our data sources on cis men were heavily biased towards MSM and other sexual minority men due to their inclusion criteria (e.g., the 2017 cycle of the NHBS among MSM and the Pride Surveys) and because cis MSM comprise the majority of the PHSKC Sexual Health Clinic patient population. Thus, we likely significantly under-sampled heterosexual identified cis men who partner with trans women and over represent the number of gay, bisexual and other sexual minority men who partner with trans women. This is important given that most heterosexual trans women report that they partner with cis men who identify as hetero- or bi-sexual and exclusively partner with cis and trans women. Although we did not see this pattern in our data, we believe it is likely to due to sampling biases. In addition, the self-reported HIV positivity and positive STI history in our study are likely overestimates due to inclusion of Sexual Health Clinic patients. In addition, there may be a small degree of overlap between our data sources as we were unable to identify duplicate participants. Lastly, the data for the present analysis came from WA state, primarily including individuals from the greater Seattle area, and may not be representative of other geographies.

Our study also relied on self-report for both HIV status and recent STI diagnoses, which may be vulnerable to recall bias, social desirability bias, and low levels of recent testing among certain subsets of our study participants. We were also unable to assess the prevalence of viral STIs, like HPV or HSV, although prior studies demonstrate that trans men who had front hole/vaginal-penile sex in the last year had a 5-fold increased odds of cervical HPV,[129] and that trans women have elevated rates of HPV.

Conclusion

Our study findings suggest there is significant heterogeneity in HIV/STI prevalence and preventative behaviors among the partners of TNB people. Sexual minority cisgender people much more commonly reported having a TNB partner in the last year (approximately 1 in 10) compared to what has been reported in previous studies, and nearly half of TNB participants reported having trans-trans partnerships in the last year. These data underscore the importance for explicitly including transgender and non-binary response options when collecting sexual partner data. It also points to the importance of broadening the inclusion criteria for MSM in HIV/STI research and surveillance to include transgender and cisgender men who have sex with transgender and/or cisgender men. Lastly, given that TNB people are diverse in their sexual and romantic partnerships, there is a need to better understand individual-, dyad-, and structural-level factors that facilitate HIV/STI prevention across these diverse partnerships.

TABLES & FIGURES

Table 3.1. Gender of Sex Partners in the last year, Stratified by Gender and Sexual Minority Status, Pooled Data for Washington State, 2017-2021

Gender of Participant	**Cis Men**		**Cis Women**		**Trans Men**		**Trans Women**		**Non-binary AFAB**	**Non-binary AMAB**
Sexual Minority Status	*Hetero-sexual*	*Sexual Minority*	*Hetero-sexual*	*Sexual Minority*	*Hetero-sexual*	*Sexual Minority*[1]	*Hetero-sexual*	*Sexual Minority*[2]	*Sexual Minority*[3]	*Sexual Minority*[4]
N	2089	4883	782	1865	17	299	85	275	725	238
Data source										
Pride 2021	0 (0.0)	609 (12.5)	0 (0.0)	889 (47.7)	1 (5.9)	134 (44.8)	6 (7.1)	66 (24.0)	394 (54.3)	76 (31.9)
Pride 2020	0 (0.0)	529 (10.8)	0 (0.0)	660 (35.4)	3 (17.6)	78 (26.1)	6 (7.1)	63 (22.9)	184 (25.4)	37 (15.5)
Pride 2019	0 (0.0)	444 (9.1)	0 (0.0)	0 (0.0)	3 (17.6)	68 (22.7)	4 (4.7)	57 (20.7)	97 (13.4)	45 (18.9)
NHBS	0 (0.0)	503 (10.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	50 (58.8)	59 (21.5)	0 (0.0)	8 (3.4)
Sexual Health Clinic	2089 (100.0)	2798 (57.3)	782 (100.0)	316 (16.9)	10 (58.8)	19 (6.4)	19 (22.4)	30 (10.9)	50 (6.9)	72 (30.3)
Gender of Sex Partners (n, %)										
Any trans or non-binary	**46 (2.2)**	**458 (9.4)**	**1 (0.1)**	**244 (13.1)**	**0 (0.0)**	**107 (35.8)**	**3 (8.3)**	**100 (44.1)**	**280 (38.6)**	**107 (46.1)**
Trans men	12 (0.6)	204 (4.2)	0 (0.0)	63 (3.4)	0 (0.0)	60 (20.1)	1 (1.2)	31 (11.3)	72 (9.9)	23 (9.7)
Trans women	23 (1.1)	108 (2.2)	0 (0.0)	49 (2.6)	0 (0.0)	26 (8.7)	1 (1.2)	75 (27.3)	82 (11.3)	28 (11.8)
Non-binary	14 (0.7)	278 (5.7)	1 (0.1)	174 (9.3)	0 (0.0)	69 (23.1)	1 (2.9)	54 (25.0)	237 (32.7)	101 (43.9)
Non-binary AMAB[5]	2 (0.1)	154 (3.9)	0 (0.0)	46 (2.5)	0 (0.0)	28 (10.6)	1 (2.9)	25 (13.0)	109 (15.4)	68 (31.9)
Non-binary AFAB[5]	13 (0.6)	60 (1.5)	0 (0.0)	120 (6.4)	0 (0.0)	43 (16.2)	0 (0.0)	27 (14.0)	165 (23.4)	39 (18.3)
Cis men	55 (2.6)	4394 (90.0)	757 (96.8)	813 (43.6)	5 (29.4)	102 (34.1)	68 (80.0)	110 (40.0)	255 (35.2)	145 (60.9)
Cis women	1986 (95.1)	458 (9.4)	21 (2.7)	730 (39.1)	9 (52.9)	85 (28.4)	3 (3.5)	63 (22.9)	190 (26.2)	51 (21.4)
Not listed/Don't know[6]							22 (25.9)	35 (12.7)		

AMAB = assigned male at birth, AFAB = assigned female at birth.

Sexual minorities included any participant who identified as gay, bisexual, queer, lesbian, pansexual, or another sexual orientation not listed. Participants in the 2019, 2020, and 2021 Pride Surveys were able to select more than one sexual orientation, so these percentages may sum to greater than 100%.

[1] Overall, 50% of trans men identified as queer, 29% as bisexual, 25% as gay, and 15% as pansexual. Only 5% identified as straight/heterosexual.

[2] Overall 26% of trans women identified as queer, 25% as lesbian, 22% as bisexual, 16% as pansexual, and 9% as gay; 24% identified as straight/heterosexual.

[3] Overall, 53% of non-binary people AMAB identified as queer, 32% as gay, 20% as pansexual, 16% as bisexual, and 4% as lesbian. Only 4 non-binary people AMAB reported being heterosexual/straight, therefore we only include sexual minority non-binary people in this table.

[4] Overall, 60% of non-binary people AFAB identified as queer, 28% as pansexual, 23% as bisexual, 15% as lesbian, and 8% as gay. Only 1 non-binary person AFAB reported being heterosexual/straight, therefore we only include sexual minority non-binary people in this table.

[5] Information about sex assigned a birth of non-binary partners was only collected at the Sexual Health Clinic, 2020 Pride Survey, and 2021 Pride Survey. Not all participants responded to this question.

[6] The NHBS survey asks about a participants most recent three sexual partners, with the following response options: Woman, Man, Transgender woman, Transgender men, A gender not listed here. Many NHBS participants reported that the gender of their partner was not listed (8.5%) or that they did not know the gender of their partner (47%).

Table 3.2. Characteristics of Participants who Reported having Trans Women Sex Partners in the last year, Stratified by Gender, Pooled Data for Washington State, 2017-2021

	Study Participants who Reported Trans Women Partners						p-value
	Cis Men	Cis Women	Non-binary AFAB	Non-binary AMAB	Trans Men	Trans Women	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	
N	131	49	82	28	26	76	
Data Source							
Pride 2021	12 (9.2)	20 (40.8)	27 (32.9)	5 (17.9)	9 (34.6)	16 (21.1)	
Pride 2020	12 (9.2)	20 (40.8)	29 (35.4)	2 (7.1)	6 (23.1)	19 (25.0)	
Pride 2019	12 (9.2)	0 (0.0)	15 (18.3)	8 (28.6)	6 (23.1)	19 (25.0)	**<0.001**
NHBS	13 (9.9)	0 (0.0)	0 (0.0)	2 (7.1)	0 (0.0)	10 (13.2)	
Sexual Health Clinic	82 (62.6)	9 (18.4)	11 (13.4)	11 (39.3)	5 (19.2)	12 (15.8)	
Sexual Orientation							
Gay	20 (15.3)	1 (2.0)	7 (8.5)	4 (14.3)	9 (34.6)	6 (7.9)	**0.001**
Straight/Heterosexual	23 (17.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.3)	**<0.001**
Bisexual	62 (47.3)	19 (38.8)	30 (36.6)	10 (35.7)	10 (38.5)	20 (26.3)	0.098
Queer	18 (15.3)	24 (49.0)	51 (62.2)	14 (50.0)	14 (53.8)	21 (27.6)	**<0.001**
Lesbian	0 (0.0)	12 (24.5)	11 (13.4)	3 (10.7)	0 (0.0)	29 (38.2)	**<0.001**
Pansexual	22 (20.8)	15 (30.6)	33 (40.2)	8 (28.6)	9 (34.6)	21 (27.6)	0.111
Gender of Additional Partners (last year)							
Only partnered with trans women	6 (4.6)	14 (28.6)	19 (23.2)	3 (10.7)	4 (15.4)	16 (21.1)	**<0.001**
Cis men	91 (69.5)	23 (46.9)	37 (45.1)	15 (53.6)	19 (73.1)	36 (47.4)	**0.001**
Cis women	96 (73.3)	24 (49.0)	25 (30.5)	11 (39.3)	7 (26.9)	34 (44.7)	**<0.001**
Trans men	34 (26.0)	8 (16.3)	24 (29.3)	8 (28.6)	10 (38.5)	17 (22.4)	0.350
Non-binary/genderqueer	44 (33.6)	16 (32.7)	53 (64.6)	23 (88.5)	17 (65.4)	36 (54.5)	**<0.001**
Income[1]							
Less than $15,000	4 (8.2)	8 (20.0)	25 (35.2)	3 (17.6)	11 (52.4)	26 (40.6)	
$15,000 to $30,000	12 (24.5)	9 (22.5)	23 (32.4)	5 (29.4)	2 (9.5)	16 (25.0)	**0.001**
$30,000 to $50,000	9 (18.4)	12 (30.0)	13 (18.3)	3 (17.6)	2 (9.5)	8 (12.5)	
more than $50,000	24 (49.0)	9 (22.5)	9 (12.7)	6 (35.3)	5 (23.8)	13 (20.3)	
Has medical insurance[1]	40 (81.6)	38 (95.0)	67 (94.4)	17 (100.0)	21 (100.0)	56 (87.5)	0.142
Unstable housing/homeless[1]	9 (18.4)	1 (2.5)	10 (14.1)	3 (17.6)	1 (4.8)	7 (10.9)	0.199
HIV Positive	7 (5.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (3.9)	**<0.001**
Currently on ART[2]	3 (75.0)					2 (66.7)	1.000
Last viral load undetectable[2]	3 (75.0)					2 (66.7)	1.000
Bacterial STI (last year)							
Any	32 (29.4)	3 (13.0)	8 (15.4)	9 (40.9)	2 (11.8)	2 (4.0)	**0.001**
Gonorrhea	19 (17.4)	1 (4.3)	6 (11.5)	4 (19.0)	1 (5.9)	1 (2.0)	0.052
Chlamydia	16 (14.7)	3 (13.0)	7 (13.5)	7 (31.8)	2 (11.8)	0 (0.0)	**0.010**
Syphilis	8 (7.3)	1 (4.3)	2 (3.9)	1 (4.8)	0 (0.0)	1 (2.0)	0.646
HIV Testing							
Ever	118 (90.1)	32 (65.3)	61 (74.4)	25 (89.3)	19 (73.1)	66 (86.8)	**0.002**
In the last year	73 (57.9)	15 (35.7)	36 (50.7)	15 (55.6)	12 (52.2)	50 (67.6)	**0.027**
STI Testing (last year) [1]	27 (55.1)	14 (35.0)	41 (57.7)	10 (58.8)	12 (57.1)	39 (60.9)	0.118

PrEP[3]							
Awareness[1]	41 (83.7)	34 (85.0)	67 (94.4)	14 (82.4)	19 (90.5)	57 (89.1)	0.447
Ever discussed with provider[1]	15 (30.6)	2 (5.0)	16 (22.5)	5 (29.4)	9 (42.9)	27 (42.2)	**0.001**
Ever Used[4]	26 (25.0)	2 (5.0)	10 (12.3)	5 (20.8)	6 (24.0)	14 (21.5)	0.057
Current Use	19 (15.3)	1 (2.0)	5 (6.1)	3 (10.7)	2 (7.7)	10 (13.7)	0.090
Reasons for not taking PrEP[1]							
Self-perceived Low Risk	12 (44.4)	28 (71.8)	50 (73.5)	7 (43.8)	9 (45.0)	23 (42.6)	**0.001**
Cost/Insurance Coverage	4 (14.8)	0 (0.0)	4 (5.9)	2 (12.5)	1 (5.0)	4 (7.4)	0.243
Don’t know where to get it	2 (7.4)	0 (0.0)	8 (11.8)	1 (6.2)	2 (10.0)	6 (11.1)	0.387
Don't know enough about PrEP	8 (29.6)	6 (15.4)	12 (17.6)	0 (0.0)	4 (20.0)	9 (18.0)	0.325
Side Effects	5 (18.5)	1 (2.6)	4 (5.9)	3 (21.4)	3 (15.0)	6 (12.0)	0.127
Wouldn't consistently take a pill	2 (7.4)	0 (0.0)	8 (11.8)	2 (14.3)	5 (25.0)	8 (16.0)	0.069
Requires too many doctor appointments	4 (14.8)	0 (0.0)	3 (4.4)	1 (7.1)	3 (15.0)	1 (2.0)	**0.040**

AFAB = assigned female at birth; AMAB = assigned male at birth; ART, antiretroviral therapy; PrEP, pre-exposure prophylaxis; STI, sexually transmitted infection.

[1] These data are not collected at the Sexual Health Clinic. These data are only from participants in the Pride Surveys and NHBS.

[2] Among HIV-positive participants

[3] Among HIV-negative participants; these variables were only collected at the Sexual Health Clinic and in the NHBS.

[4] These data are not collected at the NHBS. These data are only from participants in the Pride Surveys and Sexual Health Clinic patients.

Table 3.3. Characteristics of Participants who Reported having Trans Men Sex Partners in the last year, Stratified by Gender, Pooled Data for Washington State, 2017-2021

	Study Participants who Reported Tran Men Partners						
	Cis Men	Cis Women	Non-binary AFAB	Non-binary AMAB	Trans Men	Trans Women	p-value
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	
N	216	63	72	23	60	32	
Data Source							
Pride 2021	19 (8.8)	27 (42.9)	16 (22.2)	4 (17.4)	23 (38.3)	4 (12.5)	
Pride 2020	25 (11.6)	24 (38.1)	23 (31.9)	2 (8.7)	13 (21.7)	7 (21.9)	
Pride 2019	31 (14.4)	0 (0.0)	20 (27.8)	5 (21.7)	17 (28.3)	13 (40.6)	**<0.001**
NHBS	35 (16.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (6.2)	
Sexual Health Clinic	106 (49.1)	12 (19.0)	13 (18.1)	12 (52.2)	7 (11.7)	6 (18.8)	
Sexual Orientation							
Gay	107 (49.5)	2 (3.2)	6 (8.3)	0 (0.0)	18 (30.0)	3 (9.4)	**<0.001**
Straight/Heterosexual	12 (5.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (3.1)	0.030
Bisexual	63 (29.2)	21 (33.3)	15 (20.8)	4 (17.4)	20 (33.3)	10 (31.2)	0.411
Queer	29 (16.0)	40 (63.5)	51 (70.8)	16 (69.6)	35 (58.3)	12 (37.5)	**<0.001**
Lesbian	0 (0.0)	8 (12.7)	4 (5.6)	1 (4.3)	0 (0.0)	7 (21.9)	**<0.001**
Pansexual	21 (14.0)	17 (27.0)	20 (27.8)	8 (34.8)	6 (10.0)	11 (34.4)	**0.002**
Gender of Additional Partners (last year)							
Only partnered with trans men	4 (1.9)	25 (39.7)	11 (15.3)	0 (0.0)	21 (35.0)	3 (9.4)	**<0.001**
Cis men	195 (90.3)	25 (39.7)	32 (44.4)	17 (73.9)	23 (38.3)	18 (56.2)	**<0.001**
Cis women	80 (37.0)	26 (41.3)	28 (38.9)	10 (43.5)	18 (30.0)	16 (50.0)	0.513
Trans women	34 (15.7)	8 (12.7)	24 (33.3)	8 (34.8)	10 (16.7)	17 (53.1)	**<0.001**
Non-binary/genderqueer	75 (34.7)	22 (34.9)	58 (80.6)	21 (91.3)	30 (50.0)	22 (73.3)	**<0.001**
Income[1]							
Less than $15,000	16 (14.5)	10 (19.6)	17 (28.8)	2 (18.2)	17 (32.1)	9 (34.6)	
$15,000 to $30,000	25 (22.7)	6 (11.8)	20 (33.9)	2 (18.2)	15 (28.3)	4 (15.4)	**0.001**
$30,000 to $50,000	16 (14.5)	12 (23.5)	12 (20.3)	3 (27.3)	10 (18.9)	7 (26.9)	
more than $50,000	53 (48.2)	21 (41.2)	10 (16.9)	3 (27.3)	9 (17.0)	6 (23.1)	
Has medical insurance[1]	99 (90.0)	49 (96.1)	52 (88.1)	10 (90.9)	50 (94.3)	19 (73.1)	0.089
Unstable housing/homeless[1]	13 (11.8)	5 (9.8)	7 (11.9)	0 (0.0)	3 (5.7)	2 (7.7)	0.673
HIV Positive	29 (13.4)	0 (0.0)	0 (0.0)	2 (8.7)	0 (0.0)	0 (0.0)	**<0.001**
Currently on ART[2]	13 (86.7)			2 (100.0)			1.00
Last viral load undetectable[2]	13 (86.7)			1 (50.0)			0.772
Bacterial STI (last year)							
Any	79 (43.2)	3 (10.7)	7 (14.6)	9 (47.4)	4 (13.8)	2 (9.5)	**<0.001**
Gonorrhea	47 (25.8)	2 (7.1)	5 (10.4)	7 (36.8)	2 (6.9)	1 (4.8)	**0.002**
Chlamydia	60 (32.6)	1 (3.6)	6 (12.5)	7 (36.8)	3 (10.3)	0 (0.0)	**<0.001**
Syphilis	23 (12.5)	0 (0.0)	2 (4.3)	2 (10.5)	0 (0.0)	1 (4.8)	0.060
HIV Testing							
Ever	206 (95.4)	47 (74.6)	58 (80.6)	21 (91.3)	44 (73.3)	27 (84.4)	**<0.001**
In the last year	133 (63.6)	21 (38.9)	37 (56.1)	10 (45.5)	24 (48.0)	22 (68.8)	**0.002**
STI Testing (last year) [1]	78 (70.9)	16 (31.4)	35 (59.3)	7 (63.6)	22 (41.5)	15 (57.7)	**<0.001**

PrEP[3]							
Awareness[1]	94 (85.5)	50 (98.0)	52 (88.1)	9 (81.8)	50 (94.3)	24 (92.3)	0.131
Ever discussed with provider[1]	46 (41.8)	0 (0.0)	10 (16.9)	2 (18.2)	14 (26.4)	10 (38.5)	**<0.001**
Ever Used[4]	76 (49.7)	0 (0.0)	10 (14.3)	8 (40.0)	7 (11.7)	7 (23.3)	**<0.001**
Current Use	67 (35.8)	0 (0.0)	6 (8.3)	6 (28.6)	2 (3.3)	6 (18.8)	**<0.001**
Reasons for not taking PrEP[1]							
Self-perceived Low Risk	20 (43.5)	41 (80.4)	34 (61.8)	3 (33.3)	36 (69.2)	9 (39.1)	**<0.001**
Cost/Insurance Coverage	9 (19.6)	3 (5.9)	5 (9.1)	3 (33.3)	2 (3.8)	3 (13.0)	**0.025**
Don’t know where to get it	4 (8.7)	3 (5.9)	5 (9.1)	1 (11.1)	5 (9.6)	6 (26.1)	0.179
Don't know enough about PrEP	13 (28.3)	5 (9.8)	7 (12.7)	3 (33.3)	4 (7.7)	2 (9.5)	**0.023**
Side Effects	8 (17.4)	1 (2.0)	3 (5.5)	2 (22.2)	7 (13.5)	0 (0.0)	**0.022**
Wouldn't consistently take a pill	5 (10.9)	1 (2.0)	4 (7.3)	0 (0.0)	7 (13.5)	3 (14.3)	0.253
Requires too many doctor appointments	4 (8.7)	4 (7.8)	2 (3.6)	3 (33.3)	6 (11.5)	3 (14.3)	0.100

AFAB = assigned female at birth; AMAB = assigned male at birth; ART, antiretroviral therapy; PrEP, pre-exposure prophylaxis; STI, sexually transmitted infection.

[1] These data are not collected at the Sexual Health Clinic. These data are only from participants in the Pride Surveys and NHBS.

[2] Among HIV-positive participants

[3] Among HIV-negative participants; these variables were only collected at the Sexual Health Clinic and in the NHBS

[4] These data are not collected at the NHBS. These data are only from participants in the Pride Surveys and Sexual Health Clinic patients.

Table 3.4. Characteristics of Participants who Reported having Non-binary Sex Partners in the last year, Stratified by Gender, Pooled Data for Washington State, 2017-2021

	Study Participants who Reported Non-binary Partners						
	Cis Men	Cis Women	Non-binary AFAB	Non-binary AMAB	Trans Men	Trans Women	p-value
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	
N	292	175	237	101	69	55	
Data Source							
Pride 2021	78 (26.7)	82 (46.9)	88 (37.1)	23 (22.8)	31 (44.9)	17 (30.9)	
Pride 2020	33 (11.3)	67 (38.3)	60 (25.3)	9 (8.9)	12 (17.4)	13 (23.6)	
Pride 2019	39 (13.4)	0 (0.0)	57 (24.1)	26 (25.7)	17 (24.6)	17 (30.9)	**<0.001**
NHBS	28 (9.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
Sexual Health Clinic	114 (39.0)	26 (14.9)	32 (13.5)	43 (42.6)	9 (13.0)	8 (14.5)	
Sexual Orientation							
Gay	154 (52.7)	9 (5.1)	21 (8.9)	25 (24.8)	18 (26.1)	2 (3.6)	**<0.001**
Straight/Heterosexual	14 (4.8)	1 (0.6)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.8)	**<0.001**
Bisexual	70 (24.0)	58 (33.1)	49 (20.7)	18 (17.8)	17 (24.6)	15 (27.3)	**0.040**
Queer	59 (22.3)	80 (45.7)	174 (73.4)	68 (67.3)	48 (69.6)	23 (41.8)	**<0.001**
Lesbian	0 (0.0)	49 (28.0)	25 (10.5)	3 (3.0)	0 (0.0)	24 (43.6)	**<0.001**
Pansexual	34 (15.1)	44 (25.1)	68 (28.7)	17 (16.8)	14 (20.3)	16 (29.1)	**0.006**
Gender of Additional Partners (last year)							
Only partnered with non-binary people	14 (4.8)	48 (27.4)	69 (29.1)	6 (5.9)	8 (11.6)	9 (16.4)	**<0.001**
Cisgender men	240 (82.2)	84 (48.0)	97 (40.9)	75 (74.3)	37 (53.6)	23 (41.8)	**<0.001**
Cisgender women	93 (31.8)	97 (55.4)	92 (38.8)	28 (27.7)	28 (40.6)	25 (45.5)	**<0.001**
Transgender men	75 (25.7)	22 (12.6)	58 (24.5)	21 (20.8)	30 (43.5)	22 (40.0)	**<0.001**
Transgender women	44 (15.1)	16 (9.1)	53 (22.4)	23 (22.8)	17 (24.6)	36 (65.5)	**<0.001**
Income[1]							
Less than $15,000	21 (11.8)	31 (20.8)	55 (26.8)	8 (13.8)	15 (25.0)	13 (27.7)	
$15,000 to $30,000	31 (17.4)	23 (15.4)	49 (23.9)	15 (25.9)	19 (31.7)	9 (19.1)	**0.001**
$30,000 to $50,000	32 (18.0)	30 (20.1)	42 (20.5)	13 (22.4)	9 (15.0)	8 (17.0)	
more than $50,000	92 (51.7)	61 (40.9)	58 (28.3)	20 (34.5)	17 (28.3)	15 (31.9)	
Has medical insurance[1]	157 (88.2)	142 (95.3)	193 (94.1)	51 (87.9)	58 (96.7)	41 (87.2)	0.104
Unstable housing/homeless[1]	12 (6.7)	6 (4.0)	15 (7.3)	6 (10.3)	6 (10.0)	5 (10.6)	0.452
HIV Positive	40 (13.7)	1 (0.6)	0 (0.0)	6 (5.9)	0 (0.0)	0 (0.0)	**<0.001**
Currently on ART[2]	13 (92.9)			5 (100.0)			1.000
Last viral load undetectable[2]	14 (100.0)			4 (80.0)			0.581
Bacterial STI (last year)							
Any	73 (31.7)	8 (10.8)	12 (8.6)	33 (39.8)	5 (11.6)	3 (9.4)	**<0.001**
Gonorrhea	46 (20.1)	3 (4.1)	7 (5.0)	24 (28.9)	2 (4.7)	2 (6.1)	**<0.001**
Chlamydia	43 (18.7)	7 (9.3)	10 (7.1)	19 (23.2)	5 (11.6)	1 (3.0)	**0.001**
Syphilis	22 (9.6)	2 (2.7)	3 (2.1)	6 (7.3)	0 (0.0)	1 (3.2)	**0.012**
HIV Testing							
Ever	273 (93.5)	136 (77.7)	188 (79.3)	93 (92.1)	57 (82.6)	45 (81.8)	**<0.001**
In the last year	173 (66.0)	55 (36.9)	99 (46.0)	61 (64.2)	35 (55.6)	31 (58.5)	**<0.001**
STI Testing (last year) [1]	116 (65.2)	49 (32.9)	110 (53.7)	40 (69.0)	34 (56.7)	25 (53.2)	**<0.001**

PrEP[3]							
Awareness[1]	158 (88.8)	125 (83.9)	187 (91.2)	53 (91.4)	56 (93.3)	43 (91.5)	0.229
Ever discussed with provider[1]	75 (42.1)	8 (5.4)	31 (15.1)	26 (44.8)	21 (35.0)	19 (40.4)	**<0.001**
Ever Used[4]	98 (43.8)	4 (2.7)	19 (8.2)	41 (44.6)	14 (20.3)	14 (25.9)	**<0.001**
Current Use	73 (29.0)	1 (0.6)	10 (4.2)	26 (27.4)	4 (5.8)	7 (12.7)	**<0.001**
Reasons for not taking PrEP[1]							
Self-perceived Low Risk	40 (43.0)	102 (69.4)	147 (74.2)	16 (35.6)	31 (53.4)	22 (51.2)	**<0.001**
Cost/Insurance Coverage	15 (16.1)	5 (3.4)	13 (6.6)	5 (11.1)	3 (5.2)	3 (7.0)	**0.010**
Don't know where to get it	8 (8.6)	4 (2.7)	13 (6.6)	6 (13.3)	6 (10.3)	7 (16.3)	**0.025**
Don't know enough about PrEP	19 (20.4)	19 (12.9)	26 (13.1)	9 (20.0)	8 (13.8)	8 (18.6)	0.481
Side Effects	22 (23.7)	8 (5.4)	13 (6.6)	11 (24.4)	10 (17.2)	3 (7.0)	**<0.001**
Wouldn't consistently take a pill	9 (9.7)	1 (0.7)	12 (6.1)	4 (8.9)	8 (13.8)	6 (14.0)	**0.003**
Requires too many doctor appointments	10 (10.8)	5 (3.4)	7 (3.5)	7 (15.6)	2 (3.4)	5 (11.6)	**0.004**

AFAB = assigned female at birth; AMAB = assigned male at birth; ART, antiretroviral therapy; PrEP, pre-exposure prophylaxis; STI, sexually transmitted infection.

[1] These data are not collected at the Sexual Health Clinic. These data are only from participants in the Pride Surveys and NHBS.

[2] Among HIV-positive participants

[3] Among HIV-negative participants; these variables were only collected at the Sexual Health Clinic and in the NHBS

[4] These data are not collected at the NHBS. These data are only from participants in the Pride Surveys and Sexual Health Clinic patients.

Table 3.5. Bivariate Regression Models of HIV/STI Prevalence, Testing, and PrEP Use Associated with having a Trans Woman Sex Partner in the last year, Pooled Data for Washington State, 2017-2021

	Factors Associated With Having 1 or more Trans Women Partners					
	Cis Men Participants		Cis Women Participants		Transgender & Non-binary Participants	
	aPR (95% CI)	p-value	aPR (95% CI)	p-value	aPR (95% CI)	p-value
N	7540		2896		1648	
HIV Positive	0.53 (0.25, 1.14)	0.105			0.48 (0.15, 1.53)	0.214
Any Bacterial STI (last year)	1.34 (0.89, 2.02)	0.155	1.52 (0.45, 5.15)	0.506	0.98 (0.61, 1.57)	0.922
HIV Testing						
Ever	1.43 (0.79, 2.6)	0.236	1.22 (0.67, 2.23)	0.510	**2.22 (1.49, 3.31)**	**<0.001**
In the last year	**1.69 (1.17, 2.42)**	**0.005**	**2.08 (1.11, 3.9)**	**0.022**	**2.23 (1.66, 2.99)**	**<0.001**
STI Testing (last year) [1]	0.73 (0.4, 1.36)	0.326	1.43 (0.61, 3.35)	0.405	**2.05 (1.39, 3.02)**	**<0.001**
PrEP Use						
Awareness[1]	0.59 (0.28, 1.23)	0.159	2.12 (0.89, 5.06)	0.088	**1.85 (1.11, 3.1)**	**0.019**
Ever discussed with provider[1]	0.73 (0.4, 1.35)	0.318	**4.85 (1.17, 20.1)**	**0.029**	**2.84 (2.04, 3.95)**	**<0.001**
Ever Used	**0.34 (0.22, 0.53)**	**<0.001**	**11.6 (2.84, 48.7)**	**0.001**	**1.70 (1.14, 2.52)**	**0.009**
Current Use	0.68 (0.41, 1.1)	0.115	**33.9 (4.54, 252.2)**	**0.001**	**1.54 (0.95, 2.49)**	**0.083**

aPR, adjusted prevalence ratio; CI, confidence interval; PrEP, pre-exposure prophylaxis; STI, sexually transmitted infection.
All bivariate Poisson regression models are adjusted for the data source. Bolded results indicate factors significantly associated with the outcome variable with a p-value <0.05.
[1] These data are not collected at the Sexual Health Clinic. These data are only from participants in the Pride Surveys and NHBS.

Table 3.6. Bivariate Regression Models of HIV/STI Prevalence, Testing, and PrEP Use Associated with having a Trans Man Sex Partner in the last year, Pooled Data for Washington State, 2017-2021

	Factors Associated With Having 1 or more Trans Men Partners					
	Cis Men Participants		Cis Women Participants		Transgender & Non-binary Participants	
	aPR (95% CI)	p-value	aPR (95% CI)	p-value	aPR (95% CI)	p-value
N	7540		2896		1648	
HIV Positive	1.30 (0.88, 1.93)	0.193			0.52 (0.13, 2.13)	0.363
Any Bacterial STI (last year)	**2.43 (1.81, 3.26)**	**<0.001**	1.24 (0.37, 4.15)	0.728	1.29 (0.80, 2.10)	0.296
HIV Testing						
Ever	**2.61 (1.38, 4.94)**	**0.003**	**1.87 (1.05, 3.36)**	**0.035**	**1.90 (1.28, 2.82)**	**0.002**
In the last year	**1.84 (1.37, 2.47)**	**<0.001**	**2.55 (1.47, 4.42)**	**0.001**	**1.86 (1.37, 2.53)**	**<0.001**
STI Testing (last year) [1]	**1.65 (1.04, 2.61)**	**0.033**	1.31 (0.59, 2.89)	0.505	1.34 (0.91, 1.98)	0.138
PrEP Use						
Awareness[1]	0.81 (0.48, 1.38)	0.444	18.46 (2.55, 133.7)	0.004	**1.86 (1.07, 3.22)**	**0.028**
Ever discussed with provider[1]	1.14 (0.78, 1.66)	0.494	*NA*		**1.79 (1.21, 2.63)**	**0.003**
Ever Used	1.18 (0.85, 1.63)	0.333	*NA*		**1.61 (1.06, 2.43)**	**0.025**
Current Use	**1.98 (1.47, 2.67)**	**<0.001**	*NA*		**1.85 (1.13, 3.02)**	**0.014**

aPR, adjusted prevalence ratio; CI, confidence interval; PrEP, pre-exposure prophylaxis; STI, sexually transmitted infection.
All bivariate Poisson regression models are adjusted for the data source. Bolded results indicate factors significantly associated with the outcome variable with a p-value <0.05.
[1] These data are not collected at the Sexual Health Clinic. These data are only from participants in the Pride Surveys and NHBS.

Table 3.7. Bivariate Regression Models of HIV/STI Prevalence, Testing, and PrEP Use Associated with having a Non-binary Sex Partner in the last year, Pooled Data for Washington State, 2017-2021

	Factors Associated With Having 1 or more Non-binary Partners					
	Cis Men Participants		Cis Women Participants		Transgender & Non-binary Participants	
	aPR (95% CI)	p-value	aPR (95% CI)	p-value	aPR (95% CI)	p-value
N	7540		2896		1648	
HIV Positive	1.32 (0.94, 1.85)	0.107	1.58 (0.22, 11.33)	0.648	0.69 (0.30, 1.54)	0.362
Any Bacterial STI (last year)	**1.66 (1.26, 2.20)**	**<0.001**	1.37 (0.65, 2.88)	0.406	1.27 (0.94, 1.74)	0.125
HIV Testing						
Ever	**2.10 (1.29, 3.44)**	**0.003**	**2.47 (1.69, 3.59)**	**<0.001**	**2.60 (1.97, 3.43)**	**<0.001**
In the last year	**2.23 (1.71, 2.90)**	**<0.001**	**2.36 (1.69, 3.30)**	**<0.001**	**1.84 (1.52, 2.24)**	**<0.001**
STI Testing (last year) [1]	**1.99 (1.29, 3.05)**	**0.002**	1.32 (0.83, 2.11)	0.240	**2.12 (1.59, 2.83)**	**<0.001**
PrEP Use						
Awareness[1]	0.85 (0.53, 1.37)	0.511	**1.85 (1.21, 2.85)**	**0.005**	**2.15 (1.49, 3.11)**	**<0.001**
Ever discussed with provider[1]	**1.36 (1.01, 1.84)**	**0.040**	**5.32 (2.61, 10.85)**	**<0.001**	**2.28 (1.80, 2.90)**	**<0.001**
Ever Used	1.11 (0.85, 1.47)	0.439	**6.34 (2.35, 17.1)**	**<0.001**	**2.00 (1.55, 2.59)**	**<0.001**
Current Use	**1.60 (1.22, 2.10)**	**0.001**	**10.3 (1.42, 73.9)**	**0.021**	**1.88 (1.36, 2.58)**	**<0.001**

aPR, adjusted prevalence ratio; CI, confidence interval; PrEP, pre-exposure prophylaxis; STI, sexually transmitted infection.
All bivariate Poisson regression models are adjusted for the data source. Bolded results indicate factors significantly associated with the outcome variable with a p-value <0.05.
[1] These data are not collected at the Sexual Health Clinic. These data are only from participants in the Pride Surveys and NHBS.

Chapter 4: Population Impact of Scale-Up of HIV Testing and PrEP Among Transgender Women, Transgender Men, Non-binary People in the US: A Mathematical Modeling Analysis

ABSTRACT

Background: Few mathematical models of HIV transmission include transgender and non-binary (TNB) people. Despite TNB people being diverse in their sexual partnerships, existing models only include transgender women, and presume that they exclusively partner with cisgender men. We used a community-engaged approach to develop a novel model that more accurately represents the sexual network of TNB people and is the first to include transgender men and non-binary people. We used this model to simulate to potential impact of increasing access to PrEP and more frequent HIV testing among TNB people in the US, in order to achieve the Ending the HIV Epidemic (EHE) targets.

Methods: We developed a deterministic compartmental mathematical model using ordinary differential equations. We stratified the population by gender identity, higher/lower likelihood of HIV acquisition, HIV-status, and treatment status. The model was calibrated to 2015-2020 National HIV Surveillance data on HIV prevalence, ART use, and viral suppression.

Results: In the reference scenario, we predicted that 3,096 TNB people will acquire HIV over the 10-year period of 2020-2030. Maintaining constant rates of HIV testing and PrEP uptake, the reference scenario projected that HIV incidence among TNB populations would decrease 63-71% by 2030. A moderate 50% increase in the rate of both HIV testing and PrEP uptake among all TNB was estimated to prevent 15%, 6%, and 10% of the new HIV acquisitions between 2020-2030 among transgender women, transgender men, and non-binary people, respectively.

An optimistic scenario with a doubling in the rate of both HIV testing and PrEP uptake was estimated to reduce HIV incidence by 70-86% by 2030.

Conclusion: Similar to other modeling studies, our findings suggest substantial increases in HIV testing and PrEP uptake among TNB populations would have a large impact on HIV incidence, although the EHE target of reducing HIV incidence by 90% by 2030 will still be difficult to achieve. The development and calibration of our model was limited by the quality of data. Since national HIV surveillance data significantly underestimate the true number of TNB people living with HIV, the absolute reductions estimated in our study are also significant underestimates of the impact of the intervention scenarios considered. This modeling exercise highlights the need to for trans-inclusive HIV data collection and multilevel interventions to address structural barriers TNB people face in accessing HIV prevention services.

INTRODUCTION

In 2019, the US Department of Health and Human Services announced the Ending the HIV Epidemic (EHE) initiative, a national strategy to reduce HIV incidence by 90% by 2030.[45] Transgender and non-binary (TNB) people, especially Black, Latina, and Indigenous transgender women, have a high prevalence of HIV.[5,141] TNB people also experience significant barriers to engaging in health care, including HIV prevention and care, due to structural barriers, anti-transgender stigma, and fear of mistreatment in healthcare settings.[3,8–10] Consequently, TNB people report low levels of pre-exposure prophylaxis (PrEP) use and HIV testing relative to cisgender populations.[46,61,79,142,143] These inequities pose a challenge to the national EHE plan, which relies heavily on HIV testing and biomedical interventions, like PrEP.

Modeling is a critical tool for understanding non-linear epidemic dynamics and planning public health interventions.[144] Mathematical models of HIV have been uniquely influential in directing and evaluating HIV policy, including the development of the UNAIDS 90-90-90 targets and identifying combination interventions needed to achieve the EHE's incidence reduction goals.[145–149] However, as of August 2022, only six models of HIV transmission include transgender women, five of which are set in Lima, Peru and/or San Francisco, California.[150–155] Two of these models inappropriately aggregate transgender women with cisgender men who have sex with men (MSM), and another two models specifically focus on transgender women sex workers and their clients. Notably, there are no models that include transgender men or non-binary individuals.

TNB people are diverse in their sexual orientation and choice of sexual and romantic partners. However, existing mathematical models of HIV transmission among transgender women do not accurately represent the sexual network of transgender people and presume that transgender women exclusively partner with cisgender men. Recent data shows that although most heterosexual transgender women partner with cisgender men, only 40% of sexual minority trans women (i.e. who identity as lesbian, gay, bisexual, pansexual, and queer) reported sex with a cisgender man in the past year (Chapter 3). Transgender women also frequently report partnering with cisgender women and other transgender and non-binary people. In addition, approximately a third of transgender men and half of non-binary people self-report trans-trans partnerships within the last year.

The development of accurate and precise mathematical models of HIV that include transgender people is further limited by data availability – both for model parameterization and calibration. The majority of data on TNB populations is from convenience or clinical samples, which may overestimate HIV prevalence.[5] To date, only two representative population-based surveys have collected data on transgender identities: the Behavioral Risk Factor Surveillance System (BRFSS) and the US Transgender Population Health (TransPop) Survey.[156,157] Of these, only the TransPop survey has assessed self-reported HIV positivity among transgender and non-binary individuals. This study found that self-reported HIV positivity was 6.5% among transgender women, 0.8% among transgender men, and 5.1% among non-binary people.[158] Notably, these estimates are much lower than those estimated from meta-analyses based on convenience samples and clinical data, which report HIV prevalence of 18.8% among trans women and 2.0% among trans men.[5]

Historically, HIV surveillance data on TNB populations has been limited by the inconsistent collection and reporting of gender identity data across local jurisdictions. For example in 2015, although 83% of local public health jurisdictions collected data on TNB identities through their confidential reporting forms, only 15% reported data separately for transgender men and transgender women in their HIV Surveillance Reports.[50] The Centers for Disease Control and Prevention (CDC) first reported disaggregated HIV surveillance data for TNB people in their 2018 HIV surveillance report.[159] Thus, data on prevalence and incident HIV diagnoses for TNB people are only available dating back to 2014, and data on engagement in care (e.g., viral suppression) are only available starting in 2018. HIV surveillance data are likely significantly undercounting HIV diagnoses among TNB people due to misclassification of TNB people as cisgender. This misclassification may be most significant for non-binary people, for whom the CDC reports there were only 243 prevalent cases of HIV in 2020. This count appears to be inconsistent (by several orders of magnitude) with prevalence estimates from the TransPop study (i.e., 5.1%) applied to recent estimates of the size of the adult non-binary population in the US (i.e., 341,800).[6,158]

The present study used a community-engaged approach to develop a novel mathematical model of HIV transmission that more accurately represents the sexual network of TNB people, including trans-trans partnerships, and the first model to include transgender men and non-binary people. We used this model to simulate to potential impact of increasing access to PrEP and more frequent HIV testing among TNB people in the US, in order to achieve the EHE goals of a 90% reduction in HIV incidence by 2030.

METHODS

Mathematical Model

We developed a deterministic compartmental mathematical model using ordinary differential equations (ODEs) to simulate HIV transmission among TNB people and their sex partners in the US, and assess the benefits of increased HIV prevention utilization. The model structure was developed with input from the Seattle Trans and Non-binary Sexual Health

(STARS) Advisory Board, comprised of nine TNB individuals from the Seattle area who met bimonthly between February 2021 and July 2022.

The individuals in the simulated population were divided into seven demographic groups: transgender women, transgender men, non-binary people assigned male at birth (AMAB), non-binary people assigned female at birth (AFAB), sexual minority cisgender men, sexual minority cisgender women, and heterosexual cisgender men. We chose to disaggregate non-binary people by their sex assigned at birth due to prior research demonstrating differences in the epidemiology of HIV/STIs among non-binary people by sex assigned at birth.[105]

The model assumed that sexual partnerships occurred between all demographic groups, except that heterosexual cisgender men only partnered with transgender and cisgender women. To minimize model complexity, we chose to model first degree partnerships (e.g., TNB people and their partners), but not second degree partnerships (e.g., the partners of the partners of TNB people) with demographic groups not already included in our model. Specifically, the model excludes heterosexual cisgender women since data suggest that >99% of cisgender women who partner with transgender people identity as lesbian, gay, bisexual, pansexual or queer (see Chapter 3). However, this means our model does not account for HIV transmission patterns between cisgender men and heterosexual cisgender women. In addition to being stratified by gender identity and sexual minority status, the model was further stratified by the likelihood of HIV acquisition (e.g. higher or lower). We assumed assortative mixing among groups defined by higher/lower likelihood of HIV acquisition.

HIV-negative individuals were stratified by current PrEP use. People living with HIV were stratified by HIV stage (acute, chronic, AIDS) and by stage of HIV care engagement (undiagnosed, diagnosed and not on ART, on ART but not virally suppressed, and virally suppressed; Figure 4.1). The rates at which simulated individuals acquire HIV depends on the annual number of partners per person, sex acts per partnership, the fraction of sex acts protected by condoms and PrEP, and the HIV transmission probability per sex act with an HIV-positive partner. Complete model description including model equations is provided in Appendix D.

Model Parameterization

The model was parameterized using data from the CDC's National HIV Surveillance reports, population-based surveys, meta-analyses, and local epidemiological studies from Seattle, Washington. Since the model begins in 2014, initial conditions for the proportion of HIV-positive individuals who had acute HIV, chronic HIV, or AIDS were based on 2014 data from the CDC's National HIV Surveillance reports. Initial conditions for the proportion of individuals at each stage of the HIV care continuum were based on meta-analysis[79] and data from the National HIV Surveillance System.

Data on the proportion of people in each demographic group who have an increased likelihood of HIV acquisition were estimated using pooled 2016-2020 data from the BRFSS, which asks participants if they had experienced any of the following in the past year: injection drug use, treated for an STI, or given or received money or drugs in exchange for sex. This proportion ranged from 8.4% among trans men to 29.8% among sexual minority cis men. We similarly obtained BRFSS estimates of the proportion of individuals who tested for HIV in the past year for each demographic group stratified by higher/lower likelihood of HIV acquisition. Annual HIV testing ranged from 9.0%-22.0% among individuals with a lower likelihood of HIV acquisition and ranged from 27.4%-59.2% among individuals with a higher likelihood of HIV acquisition.

Lastly, the probabilities for sexual partnerships between all demographic groups is based on 2019-2021 data collected from participants living in Seattle and Washington State (see Chapter 3). A complete list of fixed and calibration parameters are provided in the Supplement.

Key Model Assumptions

We assumed that the initial number of TNB people diagnosed and living with HIV reported in CDC's HIV Surveillance reports in 2014 (i.e., 8076 transgender women, 282 transgender men, and 118 non-binary people) was accurate and corresponded with the self-reported HIV positivity reported in the TransPop Study (6.5%, 0.8%, and 5.1% respectively).[158] From this assumption, we back-calculated the total TNB population size to be approximately 164,000. Notably, this is 8-fold smaller than recent estimates that at least 1.3 million TNB adults currently live in the US.[6] This is likely an artifact of the significant underreporting of prevalent HIV diagnoses among TNB people in HIV surveillance data.

We also assumed that 75% of HIV diagnoses occurred among individuals with a higher likelihood of acquiring HIV. This assumption allowed for the HIV prevalence among individuals with a higher likelihood of acquiring HIV to approximate the HIV prevalence reported in recent meta-analyses based on convenience and clinical samples: approximately 19% among transgender women and 3% among transgender men.[5] Lastly, we did not differentiate between sexual role (i.e., insertive/receptive anal or vaginal/front hole sex). We instead parameterize the model based on an average transmission probability per sex act.

Model Calibration

We calibrated the model starting in 2014 and ending in 2020 by fitting the model outputs to data on HIV prevalence and the HIV care cascade for each demographic group (Table 4.1). We used count data on the number of prevalent HIV diagnoses reported in the CDC's National

HIV surveillance report from 2015-2020, which are based on laboratory testing; however, as previously discussed, these data are likely an undercount due to the misclassification of TNB people in the National HIV Surveillance Database. For the HIV care cascade, we used 2018-2020 data on viral suppression as well as data on engagement in care from the CDC's National HIV surveillance report as a proxy for current ART use.

We use a Bayesian Markov chain Monte Carlo (MCMC) framework to calibrate our model to the calibration targets described above. Bayesian frameworks enable us to update a *prior* probability distribution for a parameter, $p(\theta)$, using new data (referred to as the *likelihood*, or $p(Y|\theta)$)[160] to obtain a *posterior* distribution, $p(\theta|Y)$. This relationship can be mathematically expressed as $p(\theta|Y) \propto p(\theta) \times p(Y|\theta)$. Bayesian calibration methods thus allow us to combine three different sources of information and uncertainty: uncertainty in model parameters (e.g. by specifying *priors* for each calibration parameter), model outcomes (e.g. the *likelihood* of HIV prevalence and other calibration targets), and structural assumptions incorporated into our ODE-based mathematical model.[161] For calibration parameters, we defined priors using a uniform distribution of plausible ranges informed by the literature. We defined the likelihood using a weighted normal probability density function. We fit the model to calibration targets using 100,000 iterations to ensure MCMC convergence.

We conducted model calibration in two steps. First, we calibrated the prevalence of current PrEP use within the HIV-negative simulated population to obtain estimates of PrEP initiation and discontinuation for each demographic strata. We assumed that people with a higher likelihood of HIV acquisition were also more likely to be on PrEP than people with a lower likelihood of HIV acquisition. The resulting posterior distributions were then used as the priors in the full calibration model where we calibrate our model to HIV prevalence and the treatment cascade. After the second calibration step, we chose the best fit parameters as the maximum a posteriori (MAP), or the mode of the posterior distribution for each parameter. We then consider 100 random draws from the posterior parameter space to quantify model uncertainty. Calibration results are presented in Figure 4.2.

Simulations

The calibrated model was used to simulate the HIV epidemic from 2020-2030 under the current standard of care to provide a reference scenario for evaluating the impact of each intervention scenario. We consider a range of different intervention scenarios for TNB people. First we consider the impact of increasing the rate of HIV testing (i.e., $\sigma_{\mathrm{D}}^{i,j}$, see Figure 4.1) alone by 10%, 25%, 50%, 75% and 100%; the impact of increasing the rate of PrEP uptake (i.e., $\sigma_{\mathrm{PrEP}}^{i,j}$) alone by 10%, 25%, 50%, 75% and 100% while keeping the rate of PrEP discontinuation (i.e. $\tau_{\mathrm{PrEP}}^{i,j}$) constant; and the impact of increasing both HIV testing and PrEP initiation by 10%, 25%, 50%, 75% and 100% among all TNB people. Second, we examine the impact of targeted combined interventions (e.g. HIV testing and PrEP) only among TNB people with a higher likelihood of HIV acquisition.

Intervention Impact

We evaluated the effectiveness of each intervention scenario over the 10-year period of 2020-2030 by comparing the simulated intervention scenarios to the reference scenario. The impact was measured as the cumulative fraction of HIV transmissions prevented as well as the absolute number HIV transmissions prevented. Lastly, we estimated the percent reduction in annual HIV incidence in 2030 relative to the incidence in 2020. Notably, we will compare the estimated reduction in HIV incidence in 2030 to the EHE target of a 90% reduction in new HIV diagnoses.

RESULTS

In the reference scenario, we estimated that HIV incidence in 2020 was 3.6 per 10,000 person-years among transgender women, 2.2 per 10,000 person-years among transgender men, and 4.2 per 10,000 person-years among non-binary people (Figure 4.3). Maintaining constant rates of HIV testing and PrEP uptake, we predict that 2,461 transgender women, 532 transgender men, and 103 non-binary people will acquire HIV over the 10-year period of 2020-30, such that 16,455 transgender women, 1,523 transgender men, and 453 non-binary people would be living with HIV in the US in 2030. In the reference scenario, our model projects that HIV incidence would significantly decrease over the 10-year period, equivalent to a 70%, 63% and 71% reduction in the HIV incidence compared to 2020 among transgender women, men, and non-binary people, respectively.

We then modeled the impact of increasing the rate of HIV testing and/or PrEP uptake, assuming a constant rate of PrEP discontinuation. Table 4.2 reports the proportion of TNB people who would test for HIV annually and be on PrEP by 2030 assuming 10%, 25%, 50%, 75% and 100% increases in the rate of testing and PrEP uptake, respectively.

Across all demographic groups, increasing PrEP uptake alone had a much larger population impact compared to HIV testing alone (Figure 4.4-4.5). Combination interventions (e.g. increase both HIV testing and PrEP) provided only marginal increases in the number and percentage of HIV acquisitions that were prevented over the 10-year intervention period. Across all intervention scenarios, universal intervention approaches had a greater population-level impact for HIV prevention compared to targeted interventions (e.g. only increasing HIV testing and PrEP among individuals with a higher likelihood of HIV acquisition). The effectiveness of targeted inventions was positively correlated with the fraction of the population with a higher likelihood of HIV acquisition, which was highest among non-binary people (19%) and transgender women (14%) and lowest among transgender men (8%). Similarly, across all intervention scenarios, a larger increase in the rate of PrEP uptake is needed to prevent a similar proportion of HIV acquisition among transgender men because our model estimates a lower HIV incidence rate among transgender men compared to transgender women and non-binary people.

A moderate 50% increase in the rate of both HIV testing and PrEP uptake among all TNB people (i.e., a universal combination intervention scenario) was estimated to prevent 400 HIV acquisitions during the 10-year intervention period relative to the reference scenario, equivalent to preventing 15%, 6%, and 10% of the new HIV acquisitions projected in the reference scenario between 2020-2030 among transgender women, transgender men, and non-binary people, respectively (Figure 4.5). This scenario is equivalent to reducing HIV incidence by 67-78% by 2030, relative to 2020 (Figure 4.6).

An optimistic scenario with a doubling (100% increase) in the rate of both HIV testing and PrEP uptake among all TNB people was estimated to prevent 679 HIV acquisitions during the 10-year intervention period relative to the reference scenario, equivalent to preventing 25%, 10%, and 17% of the new HIV acquisitions between 2020-2030 among transgender women, transgender men, and non-binary people, respectively. This scenario is equivalent to reducing HIV incidence by 70-86% by 2030, relative to 2020 (Figure 4.6). Thus, even a doubling of the rate of HIV testing and PrEP uptake was not sufficient to reach the EHE target of reducing HIV incidence by 90% by 2030.

DISCUSSION

We developed a novel mathematical model of HIV transmission among all TNB people in the US that more accurately represents the sexual network of TNB people. To our knowledge, this is also the first model to include transgender men and non-binary people, despite these populations being disproportionately impacted by HIV. In our reference scenario, we predict that at least 3,096 TNB people will acquire HIV by 2030 assuming current rates of HIV testing and PrEP among TNB people in the US. Notably, this figure is almost certainly a significant underestimate given limitations of the HIV surveillance data used to calibrate our model.

Similar to other modeling studies, our findings suggest that the EHE targets will be difficult to achieve among TNB populations. We project that moderate increases in the rate of HIV testing and PrEP uptake would achieve a 67-78% reduction in HIV incidence among TNB people, which is comparable to estimates of 67% by Bradley et al.[162] and 68% by Fojo et al.[149] Overall, our findings suggest that increasing access to PrEP was significantly more effective than HIV testing at preventing HIV transmission at a population level. This points to the need to focus prevention efforts on improved access to and retention for PrEP for TNB populations.

Multilevel interventions are needed for TNB people to address the structural barriers to accessing HIV prevention and treatment**.**[163–165] Despite high reported willingness to take PrEP among transgender women and men, PrEP uptake has been low among TNB populations.[15,77,166,167] Qualitative studies have identified trans-specific barriers to PrEP, including concerns that PrEP may interact with hormone therapy, the absence of trans-inclusive marketing and public health campaigns for PrEP, stigma, and medical distrust.[19,119,168–171] Transgender participants also cited barriers that were not trans-specific, such as low awareness of PrEP, difficulty taking daily pills, side effects, and cost.[172]

An unmet need for gender-affirming health care may also hinder access HIV prevention tools for TNB people. Therefore, delivery of HIV prevention and PrEP along with gender-affirming health care, including access to gender-affirming hormones, may be effective an increasing PrEP uptake and adherence.[71,173,174] Qualitative studies based in the US have also demonstrated that fear of mistreatment in medical settings and competing priorities for accessing hormones are both barriers to PrEP uptake among transgender women. The TRIUMPH (Trans Research–Informed communities United in Mobilization for the Prevention of HIV) PrEP demonstration project found that co-administration of hormone therapy alongside PrEP significantly improved knowledge, acceptability, uptake and retention for PrEP among TNB participants.[62] Thus, receiving PrEP from trans-competent providers with training in healthcare for TNB people may be critical for PrEP uptake and adherence.[77,119]

Limitations

The development and calibration of our model was limited by the quality of data. Most notably, due to limited availability of longitudinal data on HIV prevalence for TNB people, our model assumed that the HIV prevalence reported by the CDC's National HIV Surveillance report was accurate. In actuality, these numbers are likely a gross underestimate of the true number of TNB people living with HIV, especially for transgender men and non-binary people, who are likely misclassified as cisgender. Therefore, the absolute reductions and HIV incidence rates estimated in our study are also likely significant underestimates of the impact of the intervention scenarios considered. This modeling exercise underscores the importance of trans-inclusive data collection and reporting in HIV/STI surveillance,[73] since the relevance of these analyses for informing public health decision-making is strongly dependent on the validity of the calibration targets. Therefore, it is necessary for local, state, and federal public health jurisdiction implement best practices in collecting gender identity data.

Our model should also be considered in light of the following limitations. Although there are significant racial inequities in HIV among TNB people, we were unable to include race/ethnicity our model due to very limited data available on sexual behavior, HIV prevalence, the HIV care cascade, testing or PrEP use among TNB people stratified by both gender identity and race/ethnicity. In addition, our calibrated model overestimated engagement in the HIV care cascade, and assumes an overall high level of ART use and viral suppression.

Conclusions

Modeling can be an important tool for planning public health interventions for TNB populations who are disproportionately impacted by HIV. Although we found that improving access to PrEP was effective at preventing a modest proportion of HIV transmissions by 2030, our model suggests that achieving the EHE targets among TNB populations will be difficult. This modeling exercise highlights the need to for trans-inclusive HIV data collection, the importance of reporting data disaggregated by gender identity and race/ethnicity, and the need for multilevel interventions to address structural barriers TNB people face in accessing HIV prevention services.

TABLES & FIGURES

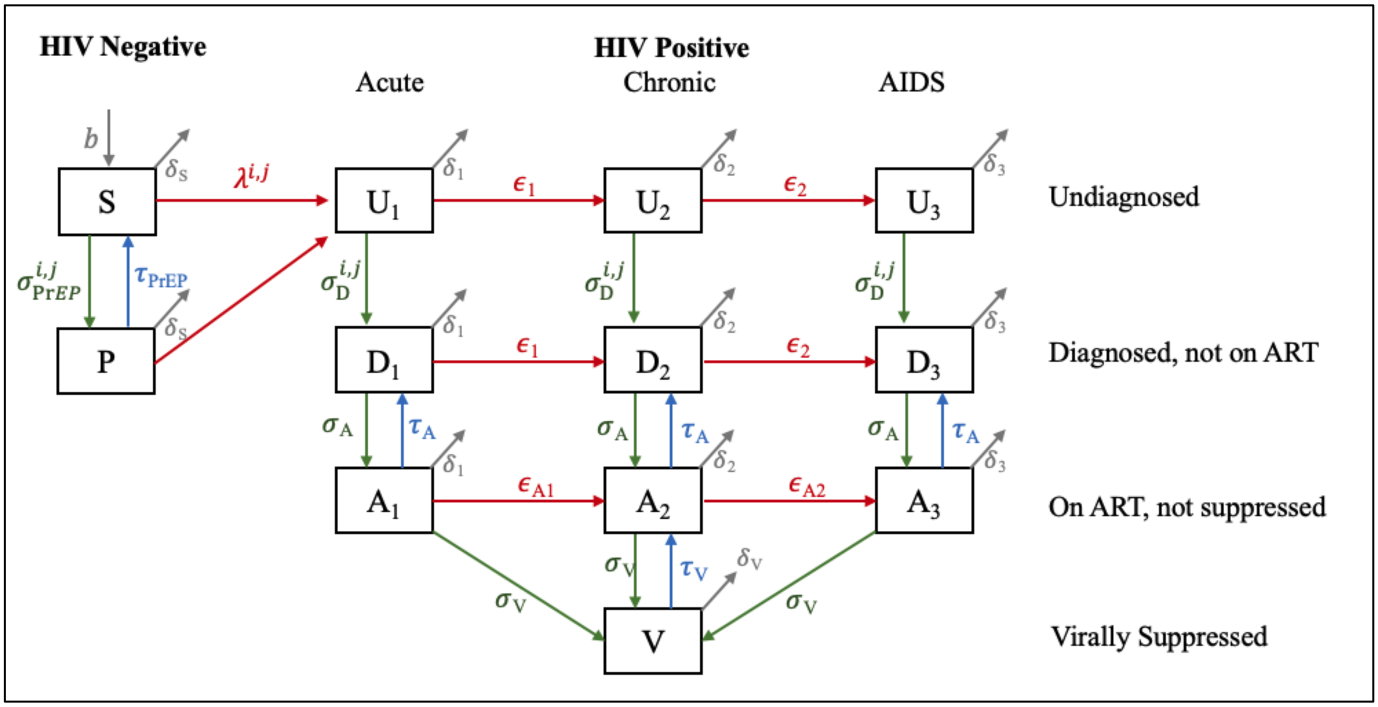


Figure 4.1. Model Schematic.

Progression along disease stages is indicated with horizontal (red) arrows and progression through HIV care engagement indicated with vertical (green and blue) arrows.

Table 4.1. Calibration targets

Target	Description	Source	Demographic Group	Value/Range
HIV Prevalence (Counts)	Number of prevalence HIV diagnoses; time series of 5 years	National HIV Surveillance Data, 2018-2020	Trans Women	10,507 – 11,949
			Trans Men	419 - 509
			Non-binary People	182 - 243
			Sexual minority cis men	574,555 – 599,433
On ART (%)	Percent who received any HIV care[1] as a proxy for receipt of ART	National HIV Surveillance Data, 2018-2020	Trans Women	83.7 – 84.4%
			Trans Men	87.1 – 85.4%
			Non-binary People	85.7 – 88.8%
			Sexual minority cis men	77.3 – 77.7%
			Sexual minority cis women[2]	75.5 – 78.8%
			Heterosexual cis men	71.1 – 71.3%
Viral Suppression (%)	Percent of diagnosed people living with HIV who are virally suppressed; 2 years of data	National HIV Surveillance Data, 2018-2020	Trans Women	64.5 – 67.0%
			Trans Men	68.3 - 71.5%
			Non-binary People	68.7 – 70.6%
			Sexual minority cis men	67.3 – 68.1%
			Sexual minority cis women[2]	63.0 – 63.1%
			Heterosexual cis men	59.8 – 64.4%
PrEP Use (%)	Percent of HIV-negative people currently using PrEP, 2019	Chapter 3	Trans Women	20%
			Trans Men	10%
			Non-binary People AMAB	30%
			Non-binary People AFAB	8%
			Sexual minority cis men	35%
			Sexual minority cis women[2]	2%
			Heterosexual cis men	15%

[1]Defined as having at least 1 CD4 or viral load test
[2]CDC does not disaggregate data specifically for sexual minority cis women. Therefore, we are using the overall rates of ART use and Viral Suppression among cisgender women overall.

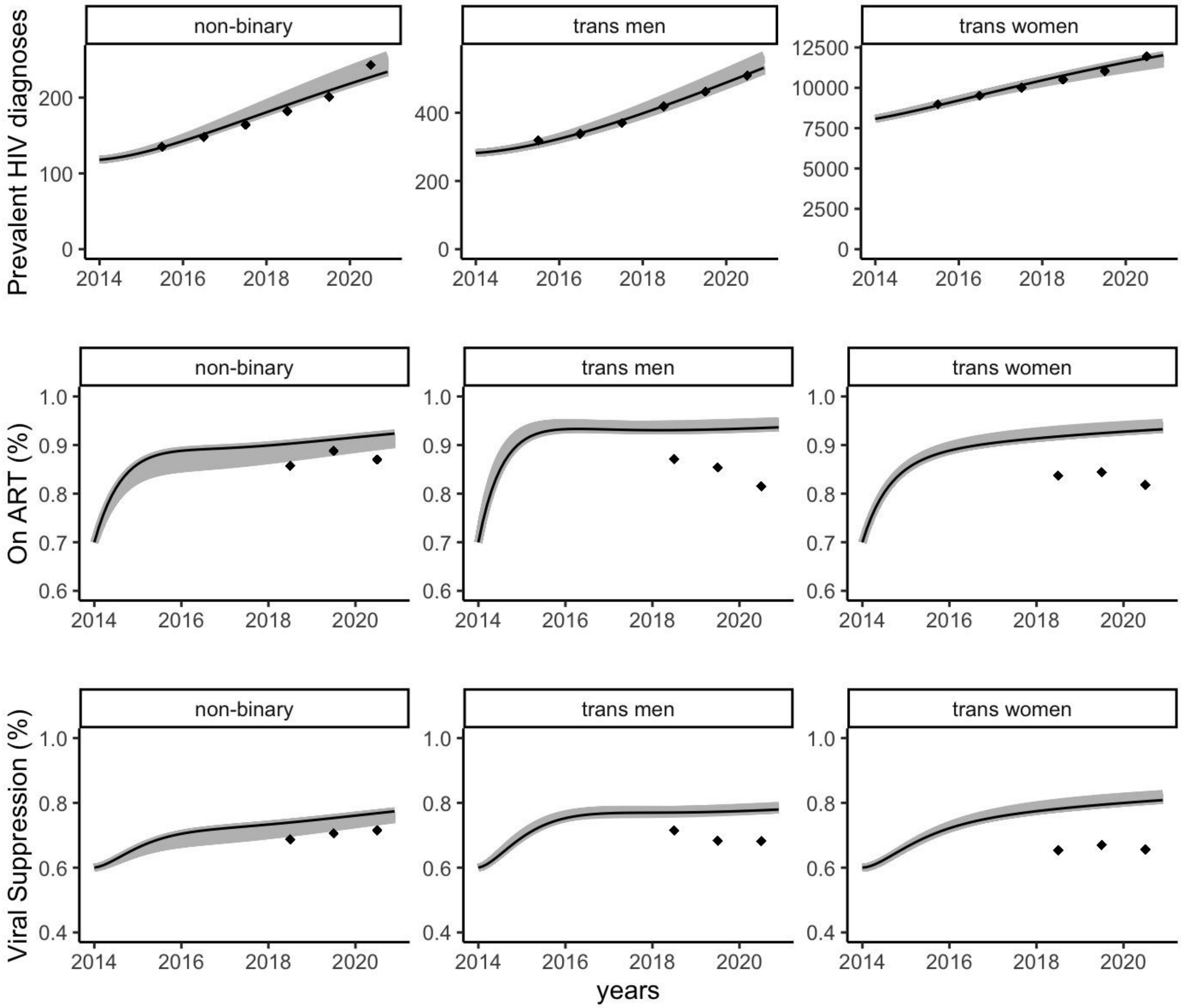


Figure 4.2. Model Calibration Results for Transgender and Non-binary Populations.

Black line indicates the best fit based on the maximum apriori (MAP) of the posterior distribution for all calibration parameters. Gray shading indicate model uncertainty based on random draws from the posterior distribution.

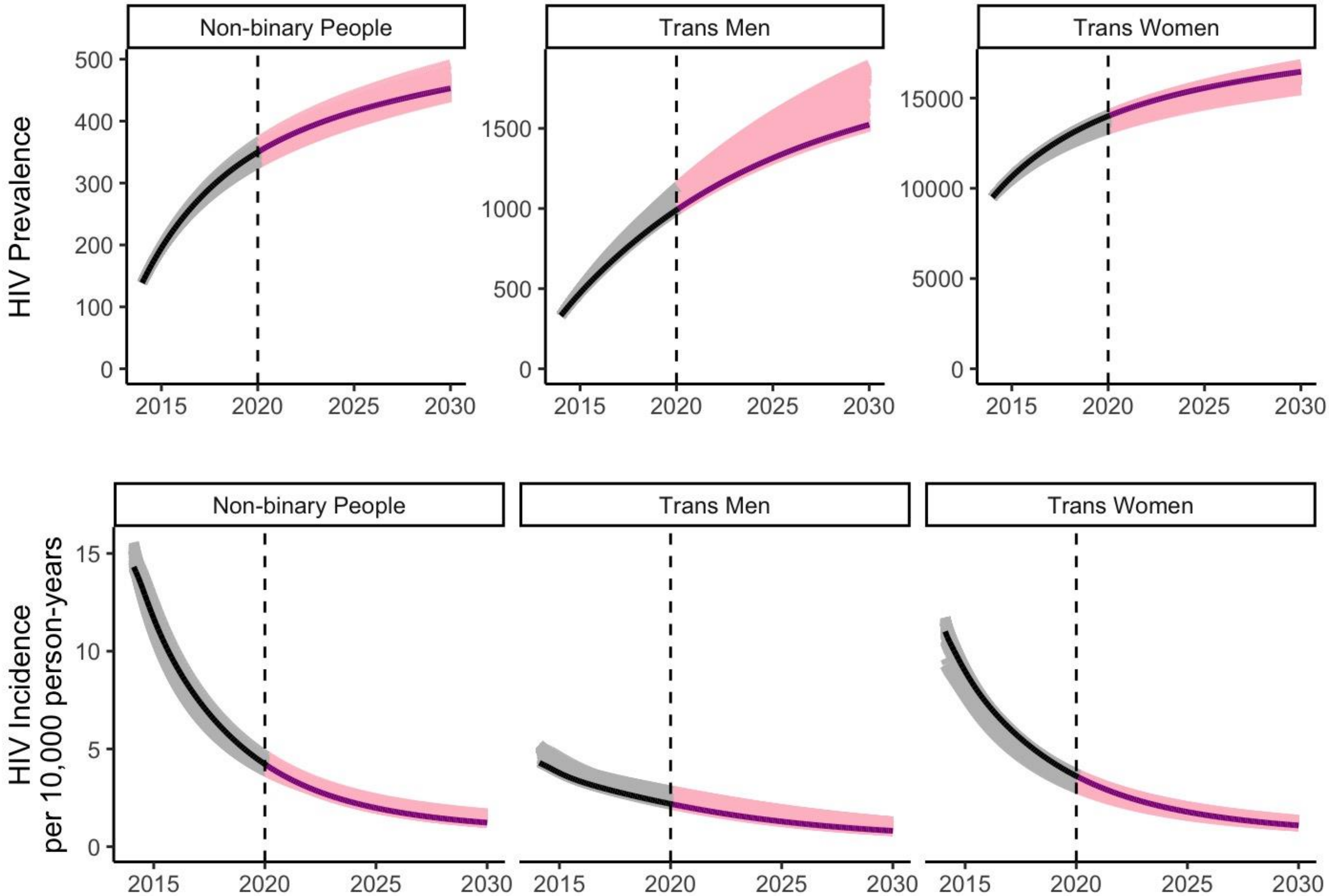


Figure 4.3. Projected HIV Prevalence and Incidence for Reference Scenario.
Line indicates the best fit based on the maximum apriori (MAP) of the posterior distribution for all calibration parameters. Shading indicate model uncertainty based on random draws from the posterior distribution. Grey/black indicate model calibration up to the year 2020, while pink/magenta indicate model projections into the future.

Table 4.2. Predicted Population Coverage for Annual HIV Testing and PrEP Use by 2030 for each Intervention Scenario, Stratified by Demographic Group and Higher/Lower Likelihood of HIV Acquisition

	Reference Scenario	**Intervention Scenario: Percent Increase in the Rate of HIV Testing and PrEP Uptake**				
		10%	25%	50%	75%	100%
Proportion Testing for HIV Annually by 2030						
Non-binary People						
Lower Likelihood of Acquiring HIV	8.2%	9.0%	10.2%	12.3%	14.3%	16.4%
Higher Likelihood of Acquiring HIV	30.5%	33.5%	38.1%	45.7%	53.4%	61.0%
Transgender Men						
Lower Likelihood of Acquiring HIV	8.2%	9.0%	10.2%	12.2%	14.3%	16.3%
Higher Likelihood of Acquiring HIV	25.1%	27.6%	31.4%	37.7%	43.9%	50.2%
Transgender Women						
Lower Likelihood of Acquiring HIV	17.5%	19.2%	21.8%	26.2%	30.6%	34.9%
Higher Likelihood of Acquiring HIV	43.7%	48.1%	54.7%	65.6%	76.5%	87.4%
Proportion on PrEP by 2030						
Non-binary People						
Lower Likelihood of Acquiring HIV	19.7%	20.9%	22.6%	25.4%	28.0%	30.4%
Higher Likelihood of Acquiring HIV	57.4%	59.4%	62.1%	66.0%	69.2%	71.8%
Transgender Men						
Lower Likelihood of Acquiring HIV	15.2%	16.2%	17.6%	19.9%	22.1%	24.3%
Higher Likelihood of Acquiring HIV	56.3%	58.6%	61.7%	66.1%	69.7%	72.8%
Transgender Women						
Lower Likelihood of Acquiring HIV	29.5%	31.1%	33.6%	37.4%	41.0%	44.3%
Higher Likelihood of Acquiring HIV	65.4%	67.5%	70.3%	74.2%	77.3%	79.8%

The proportion of participants with a higher likelihood of acquiring HIV is based on 2016-2020 data from the Behavioral Risk Factor Surveillance System (BRFSS), which asks participants if they "have injected any drug other than those prescribed for you in the past year; have been treated for an STD in the past year; or have given or received money or drugs in exchange for sex in the past year". We estimated that 14.1% of non-binary people assigned female at birth, 23.1% of non-binary people assigned male at birth, 8.4% of transgender men, and 13.7% of transgender women responded yes to this question.

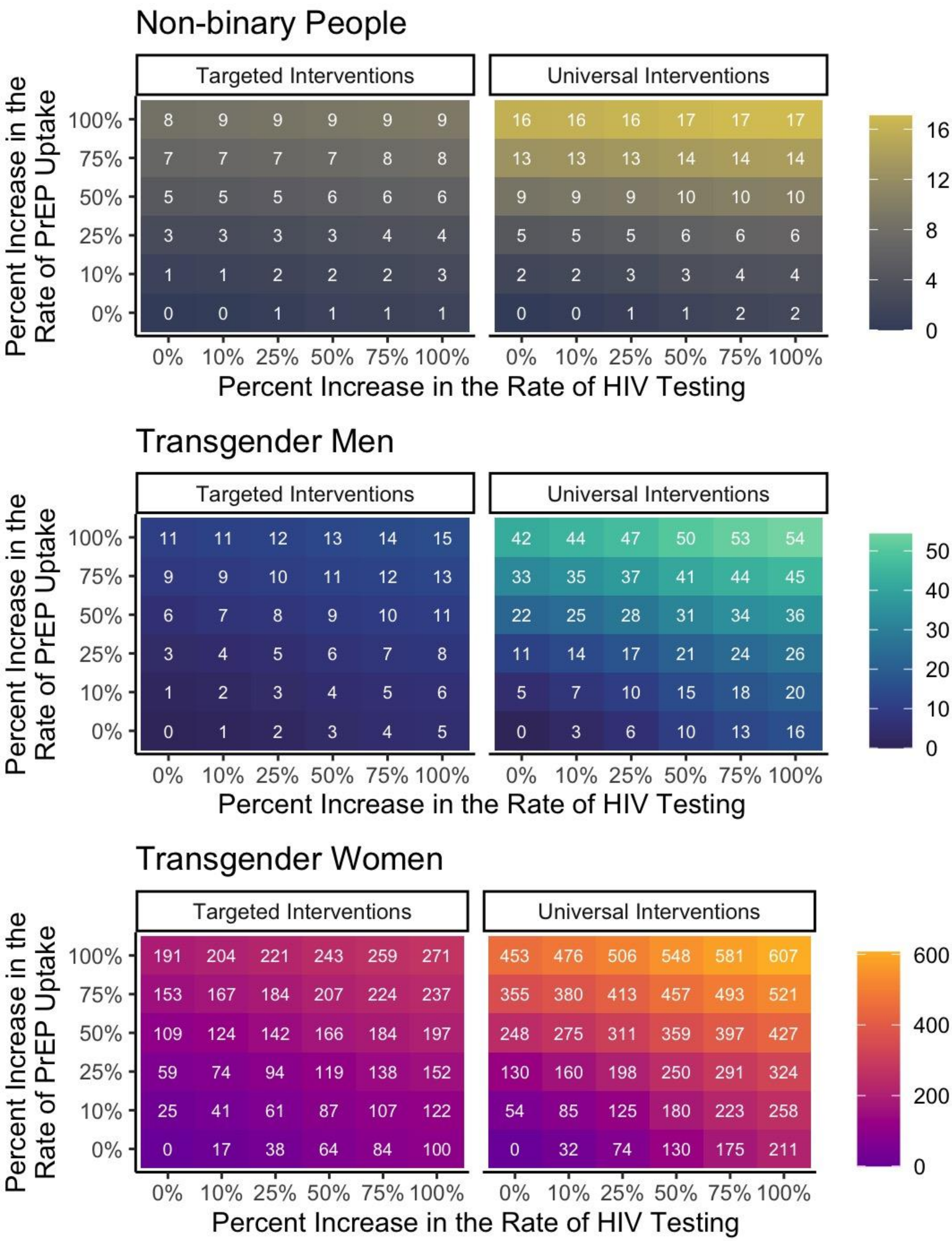


Figure 4.4. Absolute Number of New HIV Acquisitions Prevented between 2020-2030 Relative to the Reference Scenario.

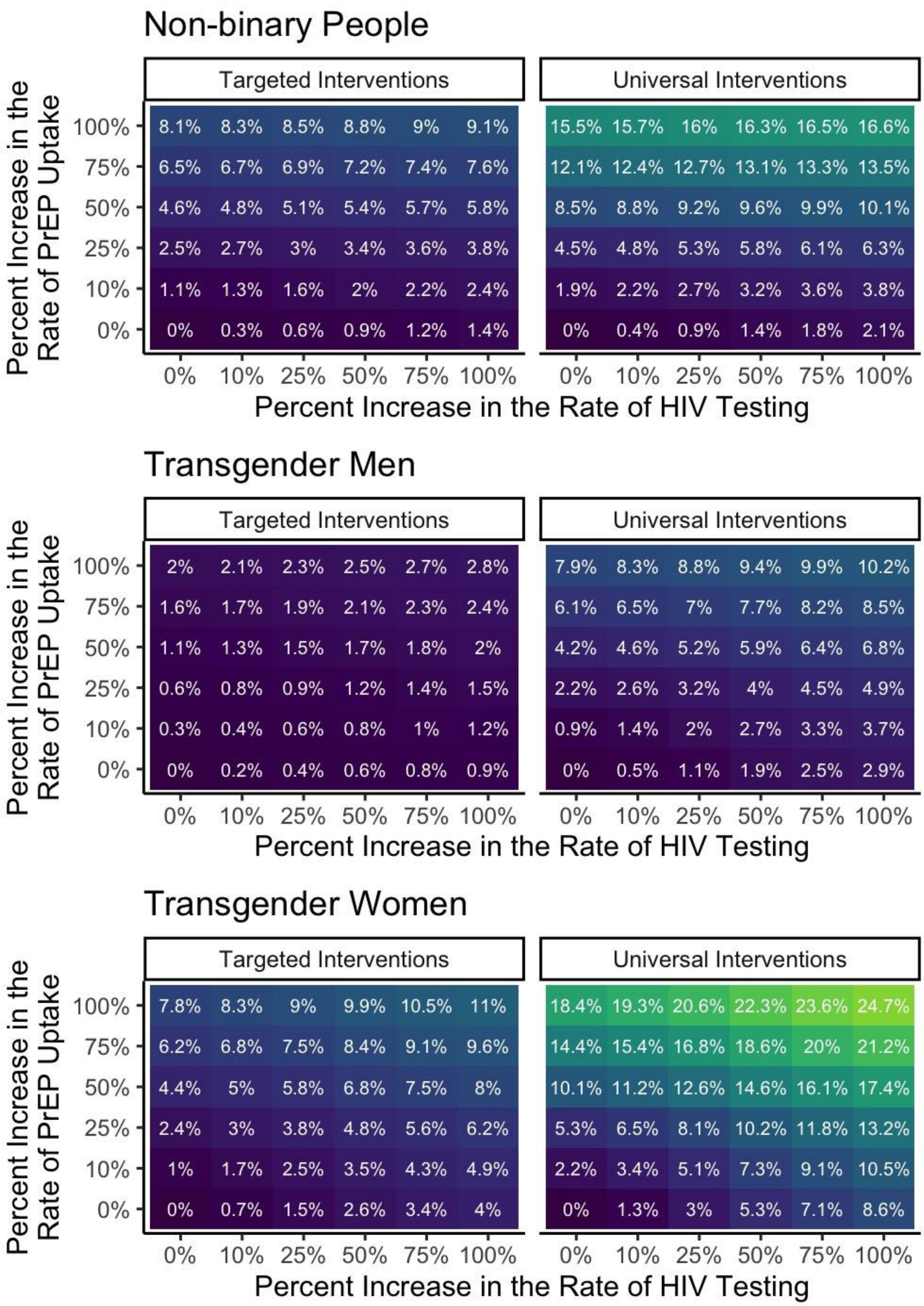


Figure 4.5. Cumulative Fraction of New HIV Acquisitions Prevented between 2020-2030 Relative to the Reference Scenario.

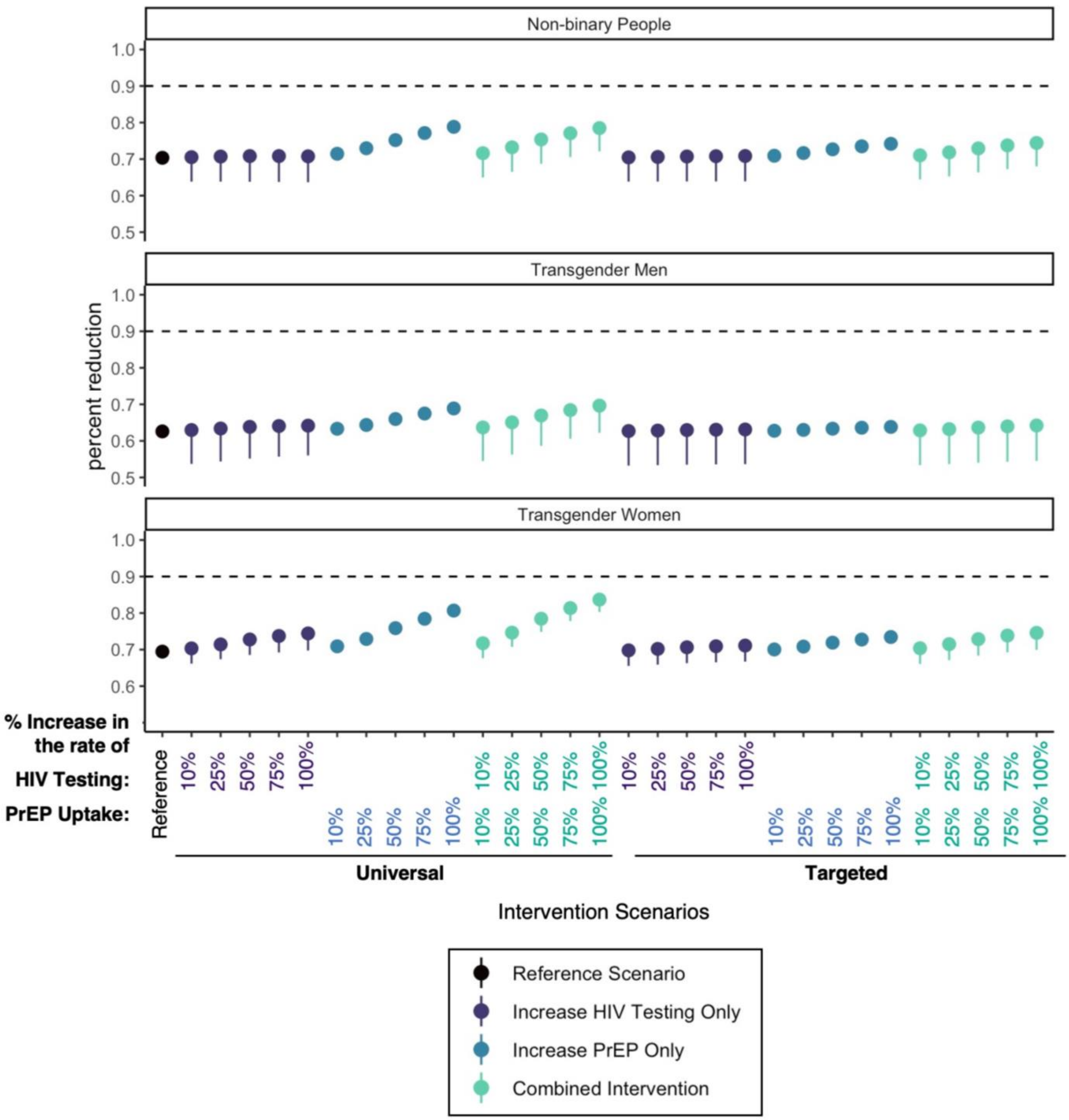


Figure 4.6. Percent Reduction in HIV Incidence Rate by 2030 Relative to 2020, by Intervention Scenario. *Point estimate indicates the best fit based on the maximum apriori (MAP) of the posterior distribution for all calibration parameters. The lines indicate model uncertainty based on random draws from the posterior distribution. Dashed line indicates the Ending HIV Epidemic goal of reducing HIV incidence by 90% by 2030.*

Conclusion

Although transgender and non-binary (TNB) people are disproportionately impacted by HIV/STIs, there also is significant heterogeneity in HIV/STI prevalence and prevention utilization within TNB communities. This heterogeneity was observed across a numbers of axes of experience, including geography, race/ethnicity, gender identity, and gender of sex partners.

In Chapter 1, we observed significant geographic variation in patterns of HIV/STI testing among TNB people by gender identity and race/ethnicity, underscoring the importance of local data on TNB communities for tailoring interventions to local or regional disparities in access to HIV/STI prevention resources. Chapter 2 highlighted how quantitative intersectionality methods can reveal heterogeneity in healthcare access and HIV/STI prevention utilization within TNB communities by gender and race/ethnicity. Chapter 3 presented data on the diversity of TNB people's sexual and romantic partnerships, and discussed the need to better understand individual-, dyad-, and structural-level factors that facilitate HIV/STI prevention across these diverse partnerships, including trans-trans partnerships. Lastly, Chapter 4 explored the feasibility of and barriers to developing a mathematical model of HIV transmission that is inclusive of transgender women, transgender men, and non-binary people to guide public health policy.

In particular, this research provides novel insights into the epidemiology of HIV/STIs of non-binary people and their partners, for whom data are infrequently available or reported. Notably, HIV/STI prevalence, testing, and PrEP use differed significantly for non-binary people by sex assigned at birth. Although non-binary people assigned male at birth (AMAB) and their cisgender male partners has the highest reported HIV/STI prevalence, these populations also reported the highest levels of engagement in HIV/STI testing and PrEP use, more so than transgender women or transgender men. In contrast, non-binary people assigned female at birth

(AFAB) had the lowest HIV/STI prevalence and prevention utilization. In Chapter 2, we also observed that patterns of intersectional synergism differ between transgender women and non-binary people AMAB. Specifically, although we saw that the intersection of gendered and racialized experience explained a large proportion of the excess prevalence of HIV/STIs among transgender women of color, this phenomena was not observed among non-binary people AMAB.

Transgender health research continues to be limited by the quality of data and its relevance to the lived experiences of TNB people. The same structural and institutional barriers that impact the health and wellbeing of TNB people also have impacted the collection and reporting of trans-inclusive data and funding of trans-specific health research. Although this body of research leveraged novel and creative analytic methods to generate knowledge from secondary data analysis, our line of investigation was limited by the questions asked and populations reached in these pre-existing data sources. Similarly, the relevance of mathematical modeling for informing public health decision-making is strongly dependent on the validity of the calibration targets obtained from national HIV surveillance data. Therefore, our findings have several important implications for research and public health practice.

First, our findings underscore the importance of using validated trans-inclusive data collection methods that explicitly include non-binary response options. National HIV surveillance data are very likely a gross underestimate of the number of TNB people living with HIV, as many TNB people (and especially non-binary people) are likely inappropriately misclassified as cisgender due to inconsistent data collection practices across local and state jurisdictions. In Chapters 1-3, we observed that disaggregating data for non-binary people (and further stratifying by their sex assigned at birth) was important for identifying inequities in health outcome and healthcare access. These findings are timely given the recent publication of the National Academy of Sciences report on *Measuring Sex, Gender Identity, and Sexual Orientation*.[175] This report recommend the use of gender identity question which omit non-binary response option and are not aligned with current best practices or recommendations from the TNB community.[176,177] Therefore, it is important to continue to advocate for the inclusion of non-binary response options in research and surveillance systems.

Second, future HIV/STI research and public health surveillance should report data for TNB people disaggregated by both gender identity and race/ethnicity. As we saw in Chapter 2, this approach is important for identifying and addressing inequities experienced by communities that live at these intersections. However, despite significant racial inequities in HIV/STI prevalence, few transgender health studies disaggregate data by race/ethnicity due to small sample sizes. The limited availability of HIV-related data disaggregated by race/ethnicity precluded our inclusion of race/ethnicity on the mathematical model presented in Chapter 4. Therefore, researchers should strive to use trans-inclusive recruitment strategies and study designs, even when not conducting trans-specific research, to help address issues of small sample sizes.

Third, our findings have important implications for data collection in Washington State. Chapters 2 and 3 leveraged all known public health data sources that collect data on TNB identities in Washington State. These existing public health data sources, most of which were originally designed for conducting HIV surveillance among cisgender MSM, do not consistently ask questions that are meaningful to the lived experiences of TNB people, and often fail to assess many structural factors that impact their access to healthcare services. In addition, these data sources disproportionately report on White participants, and do not reach the populations at highest risk of HIV, particularly Black and Spanish-speaking TNB people in Washington State. As one STARS Advisory Board members, Atlas Fernandez, shared: “data collected does not reflect the populations that are overrepresented in people living with HIV. The lack of diversity in [these studies] should sound an alarm to do better to reach people who have been marginalized by society and accurately represent them in the community.”

Finally, there is a need to move beyond descriptive epidemiology and the documentation of health inequities toward the development of evidence-based interventions for TNB people and their partners. To date, few interventions have been developed and evaluated specifically for TNB people, although several are currently underway in the U.S. and abroad.[62,174,178–185] Many of trans-specific HIV intervention models, such as *Project Lifeskills*, emphasize empowerment and resilience, and primarily use peer-navigation and a technology component.[174,178–186] Another intervention approach is the delivery of HIV treatment and PrEP coupled with gender affirming health care, including access to hormones.[62,71,187] Qualitative studies demonstrate that structural barriers, such as fear of mistreatment in medical settings and competing priorities, such as accessing hormones, are both barriers to PrEP uptake among transgender women. Thus, receiving PrEP from a trans-competent provides may be critical for PrEP uptake and adherence.[77,119] Our findings highlight the need to expand access to these trans-inclusive models[62,77,110,111] of HIV/STI prevention and PrEP delivery that also address multilevel barriers that are experienced by TNB people and their partners.

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Appendices

APPENDIX A: Methodology and Supplemental Materials for Chapter 1

i. US Transgender Survey (USTS) survey weights

The USTS used retrospective survey weights that adjusted for oversampling of 18 year-olds and White respondents. *Covariate Balance Propensity Scores* were used to adjust for measured demographic variables, including balancing the composition of 18-year-old respondents to 19-year-old respondents. The weights were further developed to match national distribution of race and ethnicity obtained from the Census Bureau's American Community Survey (ACS). The race/ethnicity categories comprised of Native American/Alaska Native, Asian/Native Hawaiian/Pacific Islander, Black, Hispanic/Latinx, White, Multiracial/Other race. Additional details on the weighting methodology are describe the US Transgender Survey's Methodology Report.

ii. Notation

- US counties are denoted by $i = 1, \ldots, I$
- Observations of individuals are denoted by $j = 1, \ldots, J$
- y_j is the outcome (e.g. HIV testing) for observation j
- u_j is the US county for observation j
- w_j is the USTS survey weight (see above) for observation j
- P_i is the US county-level prevalence of HIV testing for county i
- X_i is a vector of county-level covariate for county i

iii. Bayesian Hierarchical Model

For this analysis, we compared two estimates: direct area-level weighted Horvitz-Thompson estimates and a modeled area-level small area estimation (SAE) estimate with spatial smoothing. The Horvitz-Thompson estimates were calculated as:

$$\hat{\mathrm{P}}_{\mathrm{HT,i}} = \frac{\sum_{j=1}^{n} \mathrm{w_j y_j}}{\sum_{j=1}^{n} \mathrm{w_j}}$$

We use the three-stage model below adapted from Chen, Mercer, Wakefield, and Song.[54–57] Let $\widehat{P_i}$ be the weighted estimator of prevalence P_i with a variance estimator $\mathrm{var}(\widehat{P_i})$. We define the county-level data summary as $\theta_i = \text{logit}(\widehat{P_i}) = \log\left(\frac{\widehat{P_i}}{1-\widehat{P_i}}\right)$ as the empirical logistic transform of $\widehat{P_i}$ to constrain the probability to (0,1). Then we can specify the first stage of the model, the likelihood, as:

$$\theta_i | P_i \sim N\left(\theta_i, \frac{\text{var}(\widehat{P_i})}{\widehat{P_i}^2(1-\widehat{P_i})^2}\right)$$

The second stage of the model includes fixed overall level or "intercept" (β_0), county-level iid random effects (e_i), spatial effects (S_i), and area-level covariates (X_i):

$$\theta_i = \beta_0 + \mathbf{X}_i^{\mathrm{T}}\boldsymbol{\beta} + S_i + e_i$$

where $e_i \sim N(0, \sigma_e^2)$ and S_i follow an Intrinsic Conditional Auto-Regressive (ICAR) model for spatial smoothing. ICAR models are a class of spatial models that smooth "noisy" area-level estimates by pooling information from neighboring counties.[55,56]

In the third stage, we use the default penalized complexity prior distributions of the two hyperparameters: the spatial conditional precision $\frac{1}{\sigma_s^2}$ and the iid precision $\frac{1}{\sigma_e^2}$ parameters. The model is estimated using integrated nested Laplace approximations (INLA) for Bayesian inference.[188]

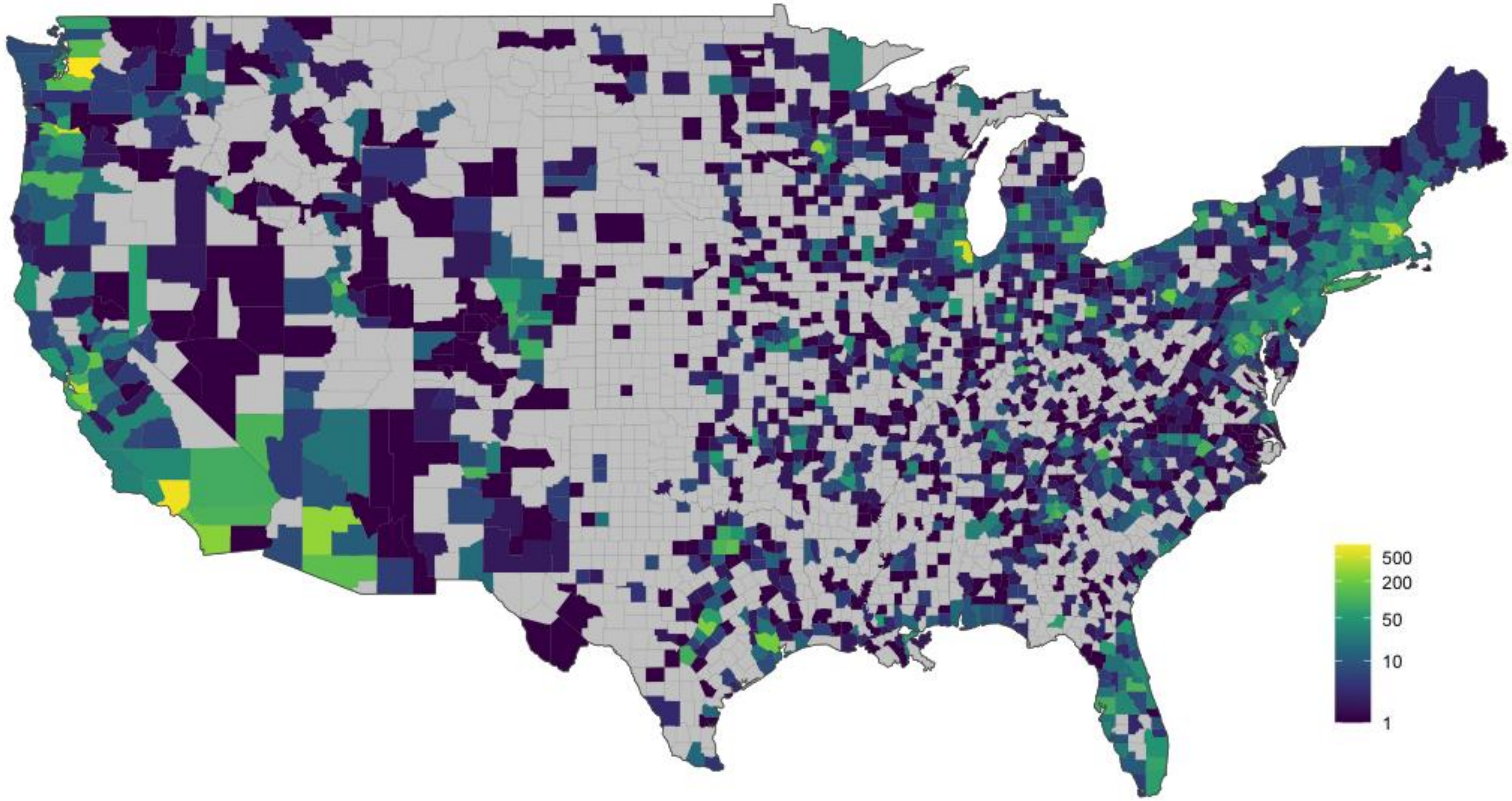
iv. Sample Sizes

Our analysis included 26,100 respondents who resided in 1,688 counties. The distribution of sample sizes within each county is reported in Supplemental Table 1.1. A map showing the distribution of the number of respondents per county is provided in Supplemental Figure 1.1.

Supplemental Table 1.1. Distribution of County-level Sample Sizes, 2015 US Transgender Survey

N Participants	N Counties	% of Counties
1-4	998	59.1%
5-9	248	14.7%
10-19	165	9.8%
20-49	152	9.0%
50-99	74	4.4%
100-499	47	2.8%
>500	4	0.2%

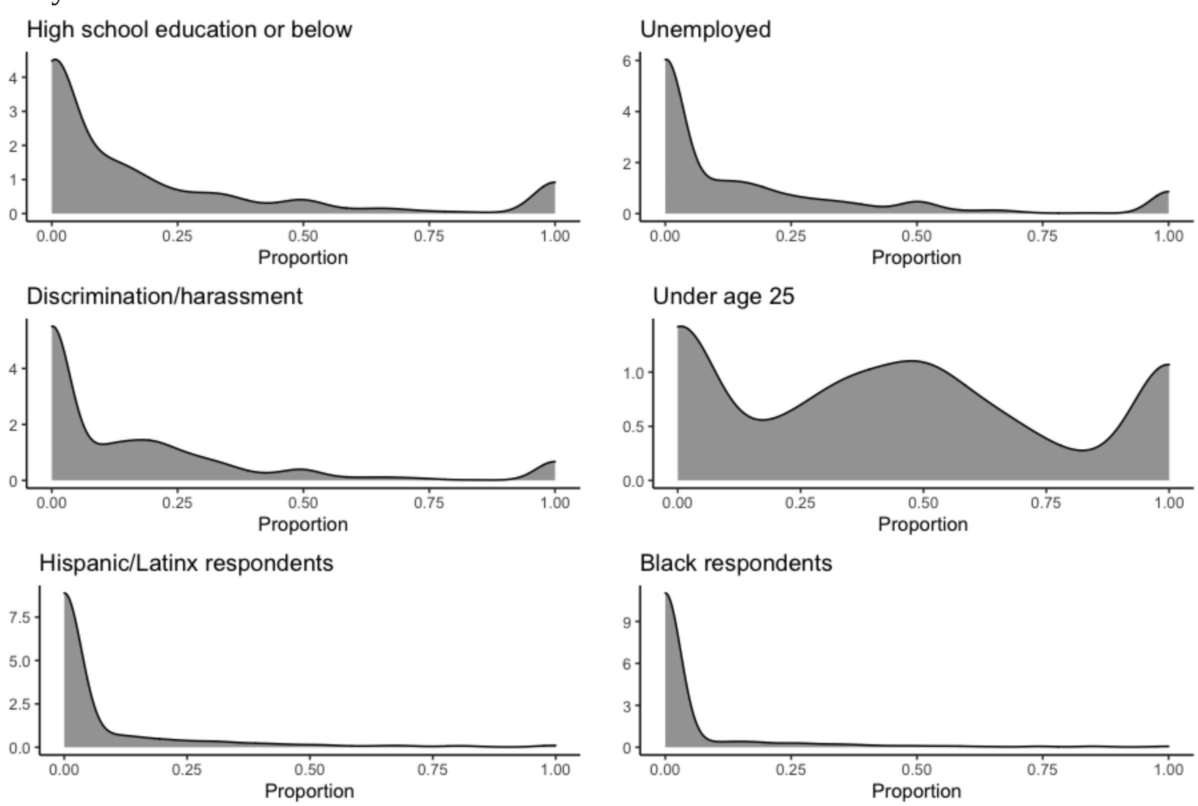
Supplemental Figure 1.1. Map of the Number of Respondents per County**,** 2015 US Transgender Survey



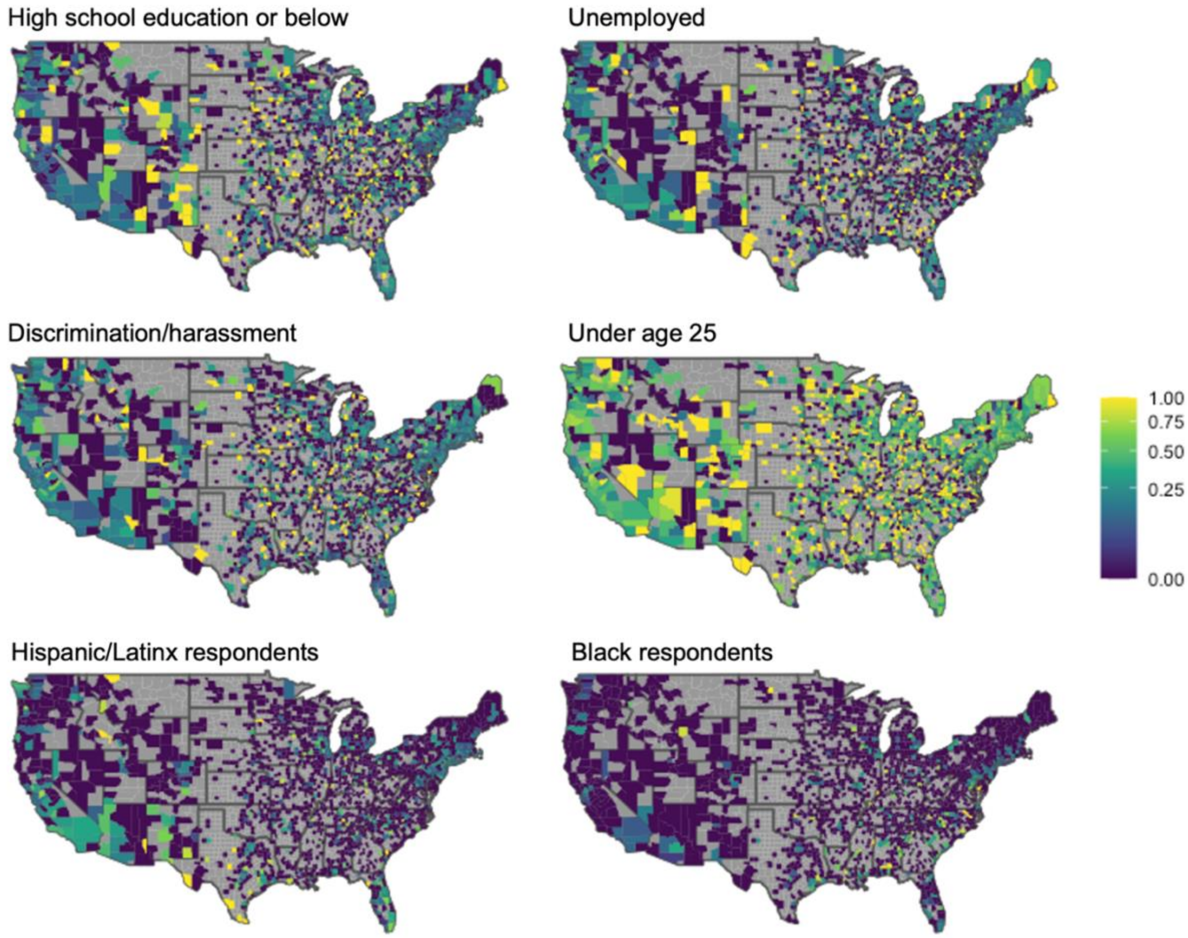
v. Model Covariates

As described above and in the main manuscript, we include six county-level covariates in the second stage of our Bayesian hierarchical model. These covariates were determined *a priori* to be associated with structural and individual-level barriers and facilitators of HIV testing. These include the proportion of USTS survey respondents who completed a high school education or less in each county; the proportion unemployed in each county; the proportion who experienced discrimination or mistreatment (e.g. denied service, harassed, attacked) in a place of public accommodation (e.g. retail stores, hotels, public transportation and government offices) in the past year; the proportion who were age <25 years old in each county; the proportion who are Black; and the proportion who are Hispanic/Latinx in each county. Below we show the density plots for these covariates in Supplemental Figure 1.2 and the geographic distribution in Supplemental Figure 1.3.

Supplemental Figure 1.2. Density Plot of County-level Covariates, 2015 US Transgender Survey



Supplemental Figure 1.3. Map of County-level Covariates, 2015 US Transgender Survey



vi. HIV testing among people excluded from the analysis

Overall, 26,100 (96.82%) participants had a valid zip code, 580 (2.15%) did not provide any zip code, and 277 (1.03%) provided an invalid zip code. HIV testing was similar among respondents who provided valid and invalid zip code, but significantly lower among respondents who did not provide a zip code (Supplemental Table 1.2). Thus, our estimates may slightly overestimate the proportion of TNB who have ever or recently tested for HIV.

Supplemental Table 1.2. HIV Testing Outcomes among Individuals Included or Excluded from the Analysis on the Basis of Zip Code, 2015 US Transgender Survey

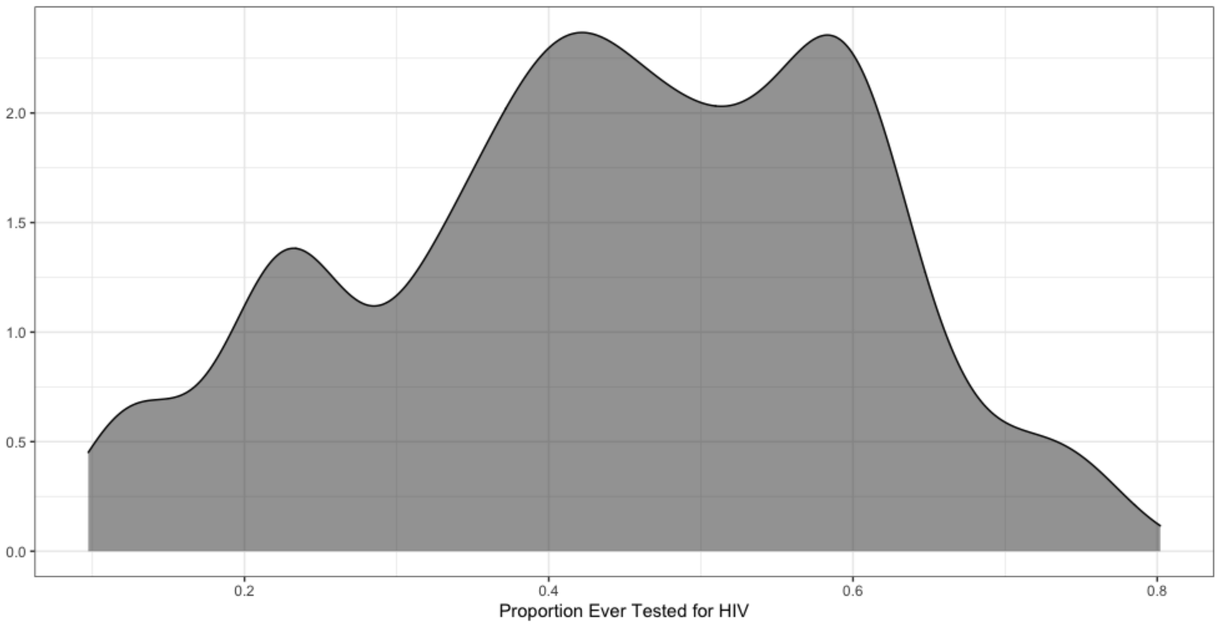
	Valid zip code	**No zip code available**	**Invalid zip code**
N	26,100	580	277
Ever tested for HIV	13,558 (51.9%)	172 (29.7%)	141 (50.9%)
Tested for HIV in the last year	5,704 (21.9%)	53 (9.1%)	57 (20.6%)

vii. Histograms of modeled estimates

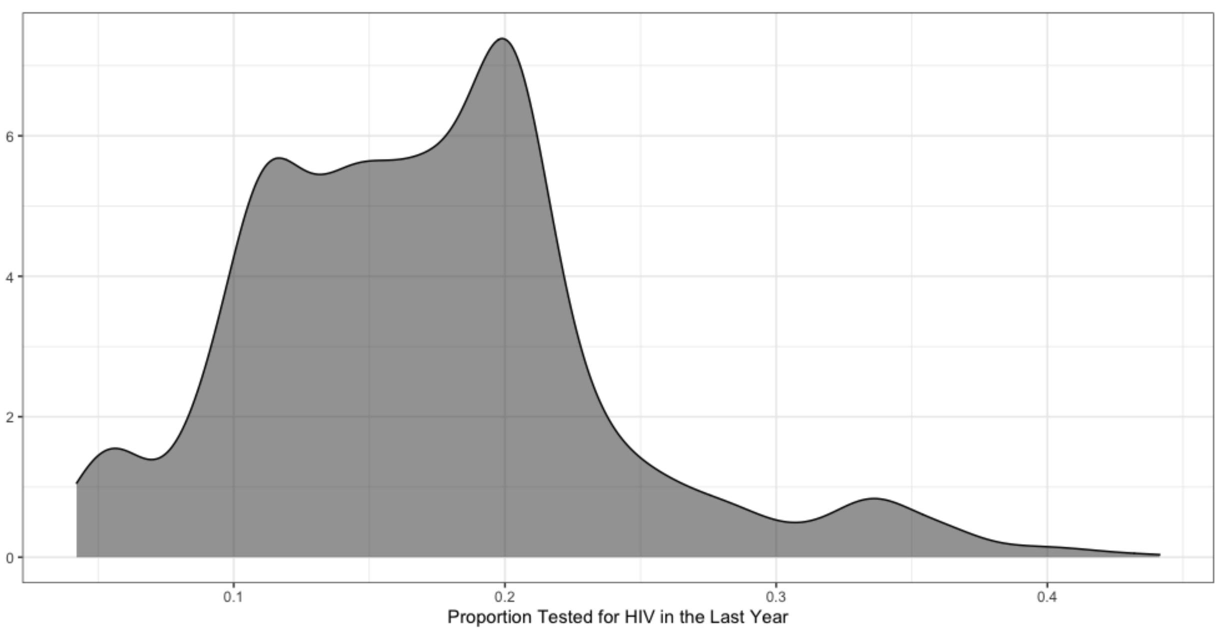
As describe in the main manuscript, modeled estimates for the county-level proportion of TNB adults who ever or recently tested for HIV varied significantly. In Supplemental Figure 1.4, we provide density plots showing the distribution of our modeled county-level estimates.

Supplemental Figure 1.4. Density Plots of the Modeled County-level Estimates, 2015 US Transgender Survey

A. Proportion ever tested for HIV

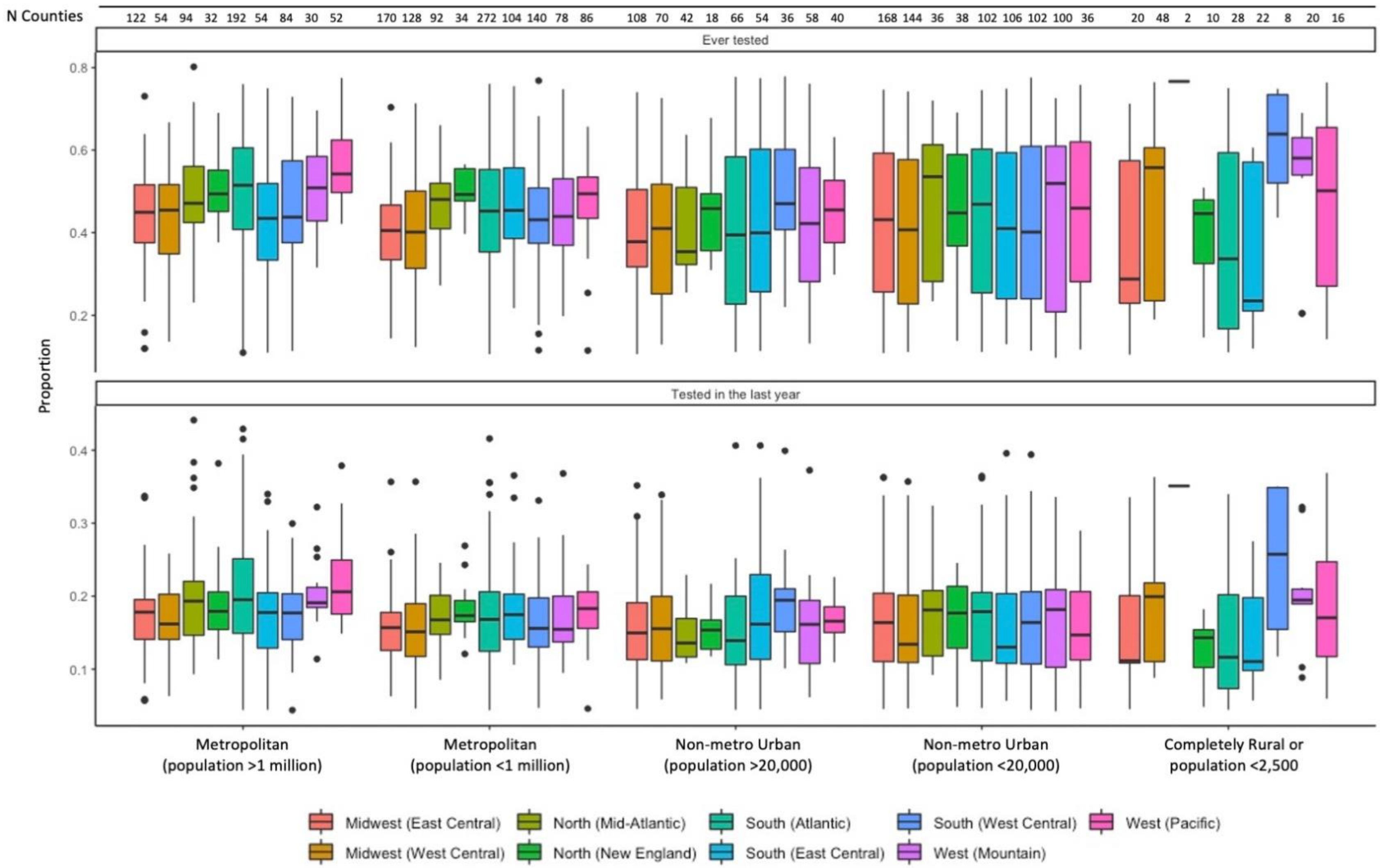


B. Proportion Tested for HIV in the Last year.



viii. Result by US region and urban/rural continuum

Supplemental Figure 1.5. Variation in the County-level Proportion of Transgender and Non-binary Adults who have Ever Tested for HIV by US Region and Urban/Rural Continuum, 2015 US Transgender Survey



ix. Comparison to the BRFSS

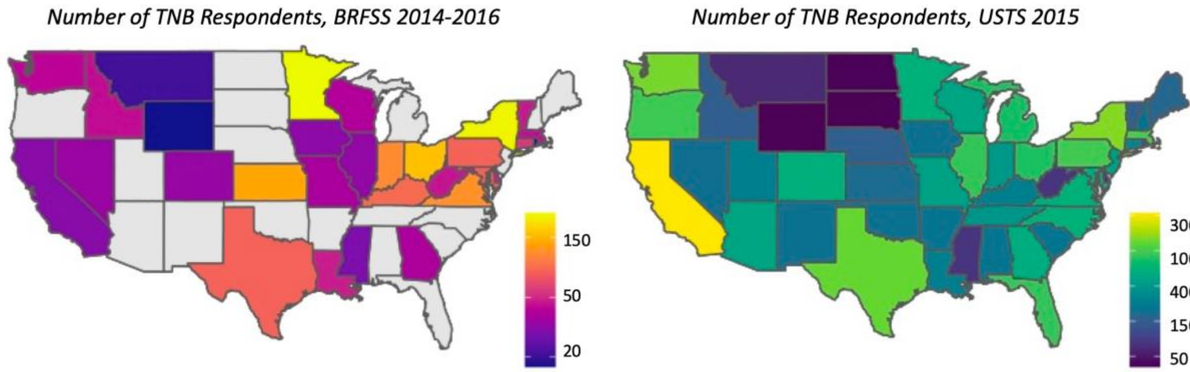
The Behavioral Risk Factor and Surveillance Survey (BRFSS) is a state-based system of telephone health surveys overseen by the Centers for Disease Control and Prevention. Eligible participants are non-institutionalized adults aged 18 or over who live in the United States. The BRFSS is a complex probability sample and uses disproportionate stratified sample so that data are collected from a representative sample within each state.[189] Beginning in 2014, the BRFSS began offering a module of sexual orientation and gender identity (SOGI) that each state could optionally include.[156] In addition, BRFSS's core questionnaire asks about ever HIV testing and date of last HIV test. The final BRFSS survey weights are calculated based on the strata weight, the number of adults per household, the number of telephones per household, and post stratification. The post stratification weight uses raking methods to further adjust their survey weights by age by sex, race and ethnicity, education, marital status, regions or counties within states, sex by race and ethnicity, telephone source, renter or owner status, and age groups by race and ethnicity.[189]

In order to increase our sample size of TNB respondents, we pooled data from 2014, 2015 and 2016 BRFSS surveys from 30 states that participated in at least one year of the sexual orientation and gender identity module (20 states participated in 2014, 21 in 2015, and 26 in 2016).[69]We applied the same statistical methods and model described in the primary text to data to estimate the prevalence of ever testing for HIV among transgender adults, except the geographic unit of analysis were states. We then compared estimates obtained from the BRFSS to those obtained from the USTS.

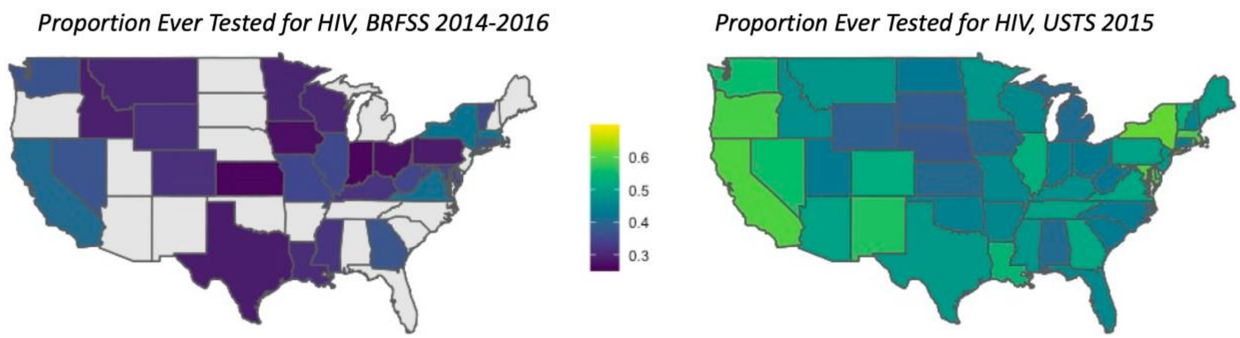
Using pooled data from the 2014-2016 BRFSS, there were 2,229 TNB respondents from 30 states. Supplemental Figure 1.6a shows the sample size by state for the BRFSS and the USTS. Overall, we observed that USTS state-level estimates are on average 17 percentage points higher (range 8-27 percentage points) than BRFSS state-level estimates (Supplemental Figure 1.7). Using pooled BRFSS data, the median proportion of TNB adults who had ever tested for HIV was 33%, and ranged between 26% in Indiana and Kentucky to 43% in Massachusetts (Supplemental Table 1.3).

Supplemental Figure 1.6

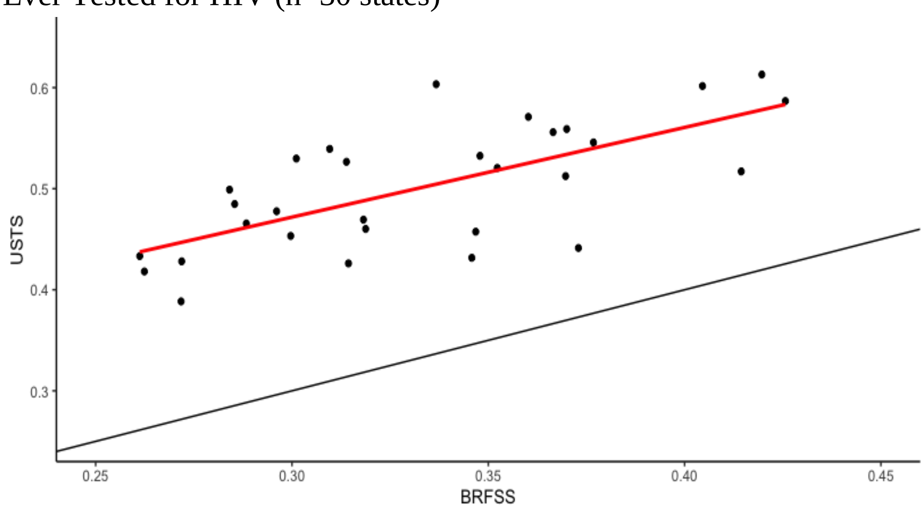
A. Number of Transgender and Non-binary Respondents to the BRFSS (N=2,229) and the 2015 US Transgender Survey (N=26,100)



B. Modeled estimate of the state-level proportion of Transgender and Non-binary Adults who have Ever Tested for HIV, Comparing results from the BRFSS to the 2015 US Transgender Survey.



Supplemental Figure 1.7. Comparing Modeled State-level Estimates for the BRFSS and the 2015 US Transgender Survey for the Proportion of Transgender and Non-binary Adults who Ever Tested for HIV (n=30 states)



Supplemental Table 1.3. State-level Proportion of Transgender and Non-binary Adults who have Ever Tested for HIV, BRFSS 2014-2016

State	N	Est. (%)	95% CI	
California	32	40.5	29.2	53.5
Colorado	35	31.4	22.0	41.8
Connecticut	60	37.3	28.4	46.8
Delaware	49	37.7	28.6	48.0
Georgia	41	37.0	27.3	47.9
Idaho	48	28.8	20.1	37.9
Illinois	34	34.8	25.5	45.9
Indiana	112	26.1	19.6	32.9
Iowa	33	27.2	18.2	36.5
Kansas	136	26.2	20.1	32.7
Kentucky	89	31.8	24.7	39.5
Louisiana	51	31.0	22.4	40.0
Maryland	83	33.7	26.2	41.7
Massachusetts	47	42.6	32.8	53.6
Minnesota	223	29.6	24.4	35.1
Mississippi	30	31.9	21.7	42.9
Missouri	40	34.7	25.6	45.3
Montana	21	30.1	19.8	41.3
Nevada	36	37.0	26.9	48.4
New York	216	42.0	36.0	48.2
Ohio	158	27.2	21.3	33.2
Pennsylvania	84	28.4	20.9	36.0
Rhode Island	20	36.0	24.7	48.4
Texas	84	28.5	21.0	36.5
Vermont	50	35.2	26.0	45.1
Virginia	117	41.4	33.8	49.7
Washington	46	36.7	26.9	47.5
West Virginia	49	34.6	26.1	44.1
Wisconsin	43	30.0	21.3	39.4
Wyoming	17	31.4	21.0	43.2

APPENDIX B: Methodology and Supplemental Materials for Chapter 2

i. Surrogate Measures of Intersectionality

Let Y refer to the outcome variable, A refer to gender (reference 0=trans men), B refer to race and ethnicity (reference 0 = White), and C refer to covariates (participants age). The prevalence of an outcome is denoted p_{ab} for groups of a specific gender and race/ethnicity adjusted for covariates (in our study, data source and participant age): $E[Y|A = a, B = b, c]$. The joint disparity along two axes (e.g. the intersection of gender and race) is described by $p_{ab} - p_{00}$, while the component disparities along a single axis of difference can be described by $p_{a0} - p_{00}$ (i.e. by gender) and $p_{ob} - p_{00}$ (i.e. by race).[108,109,190]

Measures of intersectional differences, or the joint disparity, and their calculations are presented in appendix Supplemental Table 2.1.[108,109,190–192] These values can also be estimated from regression adjusted for covariates. To estimate the risk difference (RD), we fit the following binomial model with an identity link:[193]

$$E[Y|A, B, C] = \beta_0 + \beta_1 A + \beta_2 B + \beta_3 A \times B + \beta_4 C$$
$$\text{with } Y \sim Binomial(n, p)$$

Then, conditional on the covariates, we can estimate the $RD = p_{ab} - p_{00} = \beta_1 + \beta_2 + \beta_3$.

Surrogate measures of intersectionality include the attributable proportion (AP), the ratio of observed to expected relative joint effects (RJE), the relative excess risk due to interaction (RERI), and the synergy index (SI). To estimate these surrogate measures, we fit the following Poisson regression model:

$$\log\,(E[Y|A, B, C]) = \beta_0 + \beta_1 A + \beta_2 B + \beta_3 A \times B + \beta_4 C$$

Although this model estimates the statistical interaction between gender and race on a multiplicative scale, these surrogate measures translate the RR to measures on the additive scale (Supplemental Table 1). Confidence intervals for these measures can be estimated from robust standard errors using the delta method.

Supplemental Table 2.1. Measures of Joint Disparity and Surrogate Measures of Intersectionality on the Additive Scale

Measure	Equation based on prevalence	Regression Model	Equation based on RR	Equation based on regression coefficients	Null
Risk Difference (RD)	$p_{ab} - p_{00}$	Binomial (identity link)	N/A	$\beta_1 + \beta_2 + \beta_3$	$RD = 0$
Attributable Proportion (AP)	$\frac{p_{ab} - p_{a0} - p_{0b} + p_{00}}{p_{ab}}$	Poisson	$\frac{RR_{ab} - RR_{a0} - RR_{0b} + 1}{RR_{ab}}$	$\frac{\exp(\beta_1 + \beta_2 + \beta_3) - \exp(\beta_1) - \exp(\beta_2) + 1}{\exp\,(\beta_1 + \beta_2 + \beta_3)}$	$AP = 0$
Ratio of observed to expected relative joint effects (RJE)	$\frac{p_{ab}}{p_{a0} + p_{0b} - p_{00}}$	Poisson	$\frac{RR_{ab}}{RR_{a0} + RR_{0b} - 1}$	$\frac{\exp\,(\beta_1 + \beta_2 + \beta_3)}{\exp(\beta_1) + \exp(\beta_2) - 1}$	$RJE = 1$
Relative excess risk due to interaction (RERI)	$\frac{p_{ab} - p_{a0} - p_{0b} + p_{00}}{p_{00}}$	Poisson	$RR_{ab} - RR_{a0} - RR_{0b} + 1$	$\exp(\beta_1 + \beta_2 + \beta_3) - \exp(\beta_1) - \exp(\beta_2) + 1$	$RERI = 0$
Synergy Index (SI)	$\frac{p_{ab} - p_{00}}{(p_{a0} - p_{00}) + (p_{0b} - p_{00})}$	Poisson	$\frac{RR_{ab} - 1}{(RR_{a0} - 1) + (RR_{0b} - 1)}$	$\frac{\exp(\beta_1 + \beta_2 + \beta_3) - 1}{\exp(\beta_1) + \exp(\beta_2) - 2}$	$SI = 1$

Note that $\boldsymbol{RJE} = \mathbf{1}/(\mathbf{1} - \boldsymbol{AP})$ *and* $\boldsymbol{AP} = \boldsymbol{RERI}/\boldsymbol{RR_{ab}}$

ii. Supplementary Results

Supplemental Table 2.2. Gender and Race/Ethnicity of Transgender and Non-binary Participants, Washington State, 2019-2021

		Gender				
	Overall	**Trans Men**	**Trans Women**	**Non-binary AMAB**	**Non-binary AFAB**	**p-value**
	n (%)	n (%)	n (%)	n (%)	n (%)	
Overall	1648	317 (19.2)	363 (22.0)	242 (14.7)	726 (44.1)	
Race/Ethnicity[1]						
Asian	143 (8.7)	23 (7.3)	37 (10.2)	22 (9.1)	61 (8.4)	0.576
Black	95 (5.8)	20 (6.3)	32 (8.8)	13 (5.4)	30 (4.1)	**0.018**
Hispanic/Latinx	177 (10.7)	29 (9.2)	53 (14.7)	43 (17.8)	52 (7.2)	**<0.001**
Native American/ Alaska Native	88 (5.3)	13 (4.1)	16 (4.4)	13 (5.4)	46 (6.3)	0.390
Native Hawaiian/ Pacific Islander	67 (4.1)	2 (0.6)	47 (12.9)	7 (2.9)	11 (1.5)	**<0.001**
White	1172 (71.1)	244 (77.0)	213 (58.7)	166 (68.6)	549 (75.6)	**<0.001**
Selected more than one race/ethnicity	156 (9.3)	25 (7.9)	32 (8.8)	22 (9.1)	77 (10.6)	0.524
Not listed/unknown	137 (8.1)	22 (6.9)	25 (6.9)	34 (14.0)	56 (7.7)	**0.006**

AFAB, assigned female at birth; AMAB, assigned male at birth

[1]Participants who selected more than one race/ethnicity appear in more than one row; thus percentages don't sum to 100%.

Supplemental Table 2.3. Single-Axis Participant Demographics Stratified by Gender Only, Transgender and Non-binary Participants, Washington State, 2019-2021

	Overall n (%)	**Trans Men** n (%)	**Trans Women** n (%)	**Non-Binary AMAB** n (%)	**Non-Binary AFAB** n (%)	**p-value**
N	1648	317	363	242	726	
Data Source						
Sexual Health Clinic	206 (12.5)	30 (9.5)	52 (14.3)	74 (30.6)	50 (6.9)	
Pride 2021	679 (41.2)	135 (42.6)	72 (19.8)	78 (32.2)	394 (54.3)	
Pride 2020	372 (22.6)	81 (25.6)	69 (19.0)	37 (15.3)	185 (25.5)	**<0.001**
Pride 2019	274 (16.6)	71 (22.4)	61 (16.8)	45 (18.6)	97 (13.4)	
NHBS/Project First	117 (72.7)	0 (0.0)	109 (30.0)	8 (3.3)	0 (0.0)	
Age						
24 or younger	481 (27.3)	129 (40.7)	76 (20.9)	56 (23.1)	211 (29.1)	**<0.001**
25 and older	1167 (72.7)	188 (61.4)	278 (77.9)	186 (79.8)	515 (72.5)	
Annual Income						
Less than $15,000	412 (28.6)	88 (30.7)	99 (31.8)	36 (21.4)	189 (28.0)	
$15,000 to $30,000	318 (22.1)	67 (23.3)	60 (19.3)	36 (21.4)	155 (22.9)	**0.017**
$30,000 to $50,000	264 (18.3)	43 (15.0)	47 (15.1)	38 (22.6)	136 (20.1)	
more than $50,000	372 (25.8)	66 (23.0)	93 (29.9)	52 (31.0)	161 (23.8)	
Unstable housing	98 (6.8)	13 (4.5)	41 (13.2)	15 (8.9)	29 (4.3)	**<0.001**
Has medical insurance	1304 (90.4)	269 (93.7)	259 (83.3)	151 (89.9)	625 (92.5)	**<0.001**
Regular Doctor/Provider	1105 (76.6)	233 (81.2)	226 (72.7)	123 (73.2)	523 (77.4)	0.062
HIV Testing						
Ever	1118 (67.8)	186 (58.7)	276 (76.0)	210 (86.8)	446 (61.4)	**<0.001**
Past year	525 (38.7)	84 (33.2)	165 (49.0)	120 (53.3)	156 (28.8)	**<0.001**
Past Year STI Testing	435 (30.2)	69 (24.0)	121 (38.9)	63 (37.5)	182 (26.9)	**<0.001**
HIV Positive	43 (2.6)	0 (0.0)	25 (6.9)	16 (6.6)	2 (0.3)	**<0.001**
Past Year Bacterial STI (Any)	103 (6.2)	16 (16.2)	26 (15.0)	47 (34.1)	14 (6.1)	**<0.001**
Gonorrhea	64 (3.9)	8 (8.1)	14 (8.1)	35 (25.5)	7 (3.0)	**<0.001**
Chlamydia	68 (4.1)	13 (13.1)	16 (9.3)	27 (19.7)	12 (5.2)	**<0.001**
Syphilis	19 (1.2)	1 (1.0)	8 (4.7)	7 (5.1)	3 (1.3)	0.059
Awareness/Ever heard of PrEP	1209 (83.8)	253 (88.2)	251 (80.7)	148 (88.1)	557 (82.4)	**0.024**
Ever discussed PrEP with provider	203 (21.4)	36 (12.5)	76 (24.4)	48 (28.6)	43 (6.4)	**<0.001**
PrEP Use						
Ever	90 (8.3)	26 (8.5)	32 (13.4)	60 (29.0)	22 (3.1)	**<0.001**
Current	140 (9.6)	11 (3.5)	36 (10.7)	33 (14.6)	10 (1.4)	**<0.001**

Supplemental Table 2.4. Participant Demographics Stratified by Gender and Race/Ethnicity, Transgender and Non-binary Participants, Washington State, 2019-2021

	Trans Men						
	Asian n (%)	**Black** n (%)	**Hispanic/Latinx** n (%)	**Native American/ Alaska Native** n (%)	**Native Hawaiian/ Pacific Islander** n (%)	**White** n (%)	**p-value**
N	23 (7.3)	20 (6.3)	29 (9.2)	13 (4.1)	2 (0.6)	244 (77.0)	
Age							
24 or younger	17 (77.3)	7 (35.0)	17 (58.6)	4 (33.3)	0 (0.0)	83 (35.3)	**0.001**
25 and older	5 (22.7)	13 (65.0)	12 (41.4)	8 (66.7)	2 (100.0)	152 (64.7)	
Annual Income							
Less than $15,000	6 (28.6)	5 (38.5)	10 (38.5)	2 (16.7)	0 (0.0)	72 (31.6)	0.594
$15,000 to $30,000	7 (33.3)	2 (15.4)	4 (15.4)	4 (33.3)	0 (0.0)	53 (23.2)	
$30,000 to $50,000	3 (14.3)	2 (15.4)	6 (23.1)	2 (16.7)	1 (50.0)	33 (14.5)	
more than $50,000	1 (4.8)	4 (30.8)	4 (15.4)	3 (25.0)	1 (50.0)	55 (24.1)	
Unstable housing	0 (0.0)	1 (7.7)	1 (3.8)	1 (8.3)	0 (0.0)	10 (4.4)	0.865
Has medical insurance	17 (81.0)	11 (84.6)	24 (92.3)	11 (91.7)	2 (100.0)	217 (95.2)	0.353
Regular Doctor/Provider	14 (66.7)	11 (84.6)	20 (76.9)	9 (75.0)	1 (50.0)	188 (82.5)	0.431
HIV Testing							
Ever	11 (47.8)	12 (60.0)	14 (48.3)	8 (61.5)	1 (50.0)	145 (59.4)	0.785
Past year	6 (35.3)	10 (55.6)	7 (28.0)	3 (33.3)	0 (0.0)	61 (31.1)	0.328
Past Year STI Testing	4 (19.0)	5 (38.5)	6 (23.1)	2 (16.7)	0 (0.0)	54 (23.7)	0.733
HIV Positive	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1.000
Past Year Bacterial STI (Any)	1 (4.3)	4 (20.0)	2 (6.9)	0 (0.0)	0 (0.0)	10 (4.1)	0.059
Gonorrhea	1 (4.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	6 (2.5)	0.838
Chlamydia	1 (4.3)	4 (20.0)	2 (6.9)	0 (0.0)	0 (0.0)	7 (2.9)	**0.012**
Syphilis	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.4)	0.996
Ever heard of PrEP	19 (90.5)	11 (84.6)	23 (88.5)	10 (83.3)	1 (50.0)	201 (88.2)	0.672
Ever discussed PrEP with provider	5 (23.8)	3 (23.1)	1 (3.8)	3 (25.0)	0 (0.0)	27 (11.8)	0.193
PrEP Use							
Ever	4 (18.2)	5 (31.2)	1 (3.7)	1 (7.7)	0 (0.0)	18 (7.5)	**0.018**
Current	1 (4.3)	3 (15.0)	1 (3.4)	0 (0.0)	0 (0.0)	7 (2.9)	0.135

Supplemental Table 2.4 cont.

	Trans Women						
	Asian n (%)	**Black** n (%)	**Hispanic/Latinx** n (%)	**Native American/ Alaska Native** n (%)	**Native Hawaiian/ Pacific Islander** n (%)	**White** n (%)	**p-value**
N	37 (10.2)	32 (8.8)	53 (14.7)	16 (4.4)	47 (12.9)	213 (58.7)	
Age							
24 or younger	9 (25.0)	9 (28.1)	10 (19.2)	7 (43.8)	3 (6.4)	52 (24.9)	**0.027**
25 and older	27 (75.0)	23 (71.9)	42 (80.8)	9 (56.2)	44 (93.6)	157 (75.1)	
Annual Income							
Less than $15,000	5 (15.6)	12 (48.0)	16 (39.0)	5 (35.7)	10 (22.7)	59 (33.0)	**0.003**
$15,000 to $30,000	6 (18.8)	6 (24.0)	6 (14.6)	0 (0.0)	11 (25.0)	33 (18.4)	
$30,000 to $50,000	8 (25.0)	4 (16.0)	10 (24.4)	6 (42.9)	7 (15.9)	22 (12.3)	
more than $50,000	12 (37.5)	3 (12.0)	4 (9.8)	2 (14.3)	16 (36.4)	58 (32.4)	
Unstable housing	1 (3.1)	7 (28.0)	6 (14.6)	2 (14.3)	8 (18.2)	20 (11.2)	**0.096**
Has medical insurance	23 (71.9)	21 (84.0)	23 (56.1)	8 (57.1)	29 (65.9)	168 (93.9)	**<0.001**
Regular Doctor/Provider	21 (65.6)	13 (52.0)	29 (70.7)	10 (71.4)	23 (52.3)	146 (81.6)	**<0.001**
HIV Testing							
Ever	29 (78.4)	31 (96.9)	46 (86.8)	13 (81.2)	37 (78.7)	150 (70.4)	**0.009**
Past year	18 (51.4)	18 (56.2)	30 (60.0)	9 (60.0)	25 (53.2)	83 (43.2)	0.238
Past Year STI Testing	11 (34.4)	15 (60.0)	24 (58.5)	9 (64.3)	21 (47.7)	54 (30.2)	**<0.001**
HIV Positive	0 (0.0)	9 (28.1)	8 (15.1)	1 (6.2)	5 (10.6)	7 (3.3)	**<0.001**
Past Year Bacterial STI (Any)	2 (5.4)	8 (25.0)	7 (13.2)	2 (12.5)	7 (14.9)	10 (4.7)	**0.002**
Gonorrhea	2 (5.4)	4 (12.5)	5 (9.4)	1 (6.2)	5 (10.6)	5 (2.3)	0.051
Chlamydia	1 (2.7)	4 (12.5)	3 (5.7)	1 (6.2)	4 (8.5)	5 (2.3)	0.096
Syphilis	0 (0.0)	3 (9.4)	2 (3.8)	0 (0.0)	1 (2.1)	4 (1.9)	0.143
Ever heard of PrEP	22 (68.8)	22 (88.0)	32 (78.0)	11 (78.6)	35 (79.5)	146 (81.6)	0.560
Ever discussed PrEP with provider	8 (25.0)	9 (36.0)	12 (29.3)	5 (35.7)	16 (36.4)	33 (18.4)	0.073
PrEP Use							
Ever	3 (14.3)	6 (54.5)	8 (33.3)	2 (25.0)	2 (33.3)	16 (8.9)	**<0.001**
Current	6 (16.2)	6 (26.1)	9 (20.0)	5 (33.3)	5 (11.9)	14 (6.8)	**0.002**

Supplemental Table 2.4 cont.

	Non-binary AMAB						
	Asian n (%)	**Black** n (%)	**Hispanic/Latinx** n (%)	**Native American/ Alaska Native** n (%)	**Native Hawaiian/ Pacific Islander** n (%)	**White** n (%)	**p-value**
N	22 (9.1)	13 (5.4)	43 (17.8)	13 (5.4)	7 (2.9)	166 (68.6)	
Age							
24 or younger	2 (9.1)	2 (15.4)	13 (31.7)	2 (16.7)	0 (0.0)	35 (21.7)	0.222
25 and older	20 (90.9)	11 (84.6)	28 (68.3)	10 (83.3)	7 (100.0)	126 (78.3)	
Annual Income							
Less than $15,000	4 (25.0)	4 (57.1)	11 (33.3)	3 (25.0)	2 (28.6)	22 (19.6)	0.438
$15,000 to $30,000	2 (12.5)	1 (14.3)	5 (15.2)	3 (25.0)	1 (14.3)	26 (23.2)	
$30,000 to $50,000	3 (18.8)	0 (0.0)	8 (24.2)	4 (33.3)	0 (0.0)	25 (22.3)	
more than $50,000	5 (31.2)	1 (14.3)	8 (24.2)	2 (16.7)	3 (42.9)	36 (32.1)	
Unstable housing	1 (6.2)	5 (71.4)	4 (12.1)	3 (25.0)	2 (28.6)	6 (5.4)	**<0.001**
Has medical insurance	15 (93.8)	6 (85.7)	29 (87.9)	11 (91.7)	7 (100.0)	100 (89.3)	0.193
Regular Doctor/Provider	15 (93.8)	4 (57.1)	25 (75.8)	5 (41.7)	7 (100.0)	82 (73.2)	**0.021**
HIV Testing							
Ever	18 (81.8)	12 (92.3)	38 (88.4)	12 (92.3)	7 (100.0)	141 (84.9)	0.745
Past year	9 (42.9)	7 (53.8)	25 (67.6)	6 (46.2)	4 (57.1)	84 (55.3)	0.546
Past Year STI Testing	2 (12.5)	5 (71.4)	14 (42.4)	6 (50.0)	1 (14.3)	44 (39.3)	0.064
HIV Positive	4 (18.2)	3 (23.1)	2 (4.7)	0 (0.0)	0 (0.0)	7 (4.2)	**0.012**
Past Year Bacterial STI (Any)	5 (22.7)	4 (30.8)	12 (27.9)	1 (7.7)	1 (14.3)	31 (18.7)	0.524
Gonorrhea	4 (18.2)	4 (30.8)	7 (16.3)	1 (7.7)	1 (14.3)	23 (13.9)	0.631
Chlamydia	4 (18.2)	2 (15.4)	8 (18.6)	0 (0.0)	0 (0.0)	18 (10.8)	0.347
Syphilis	0 (0.0)	1 (7.7)	2 (4.7)	0 (0.0)	0 (0.0)	5 (3.0)	0.752
Awareness/Ever heard of PrEP	13 (81.2)	6 (85.7)	30 (90.9)	12 (100.0)	7 (100.0)	98 (87.5)	0.592
Ever discussed PrEP with provider	2 (12.5)	4 (57.1)	12 (36.4)	5 (41.7)	0 (0.0)	33 (29.5)	0.100
PrEP Use							
Ever	3 (18.8)	2 (28.6)	20 (50.0)	4 (30.8)	1 (16.7)	40 (27.4)	0.094
Current	0 (0.0)	2 (20.0)	14 (34.1)	3 (23.1)	0 (0.0)	24 (15.1)	**0.014**

Supplemental Table 2.4 cont.

	Non-binary AFAB						
	Asian n (%)	**Black** n (%)	**Hispanic/Latinx** n (%)	**Native American/ Alaska Native** n (%)	**Native Hawaiian/ Pacific Islander** n (%)	**White** n (%)	**p-value**
N	61 (8.4)	30 (4.1)	52 (7.2)	46 (6.3)	11 (1.5)	549 (75.6)	
Age							
24 or younger	24 (40.0)	15 (50.0)	17 (34.0)	14 (31.8)	4 (36.4)	141 (26.3)	
25 and older	36 (60.0)	15 (50.0)	33 (66.0)	30 (68.2)	7 (63.6)	396 (73.7)	**0.025**
Annual Income							
Less than $15,000	21 (34.4)	6 (24.0)	14 (29.2)	18 (40.9)	5 (45.5)	141 (27.4)	
$15,000 to $30,000	10 (16.4)	6 (24.0)	14 (29.2)	9 (20.5)	6 (54.5)	118 (23.0)	0.130
$30,000 to $50,000	11 (18.0)	4 (16.0)	10 (20.8)	8 (18.2)	0 (0.0)	102 (19.8)	
more than $50,000	14 (23.0)	5 (20.0)	8 (16.7)	7 (15.9)	0 (0.0)	130 (25.3)	
Unstable housing	6 (9.8)	4 (16.0)	5 (10.4)	5 (11.4)	2 (18.2)	16 (3.1)	**0.001**
Has medical insurance	54 (88.5)	25 (100.0)	42 (87.5)	39 (88.6)	11 (100.0)	482 (93.8)	**0.036**
Regular Doctor/Provider	52 (85.2)	19 (76.0)	33 (68.8)	34 (77.3)	10 (90.9)	399 (77.6)	0.370
HIV Testing							
Ever	30 (49.2)	19 (63.3)	36 (69.2)	30 (65.2)	7 (63.6)	339 (61.7)	0.350
Past year	13 (31.0)	10 (45.5)	10 (24.4)	9 (25.7)	3 (37.5)	120 (28.9)	0.577
Past Year STI Testing	19 (31.1)	11 (44.0)	11 (22.9)	10 (22.7)	4 (36.4)	139 (27.0)	0.380
HIV Positive	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.4)	0.981
Past Year Bacterial STI (Any)	3 (4.9)	3 (10.0)	2 (3.8)	3 (6.5)	2 (18.2)	5 (0.9)	**<0.001**
Gonorrhea	1 (1.6)	3 (10.0)	2 (3.8)	2 (4.3)	1 (9.1)	3 (0.5)	**<0.001**
Chlamydia	3 (4.9)	3 (10.0)	2 (3.8)	3 (6.5)	2 (18.2)	3 (0.5)	**<0.001**
Syphilis	1 (1.6)	1 (3.3)	1 (1.9)	1 (2.2)	1 (9.1)	1 (0.2)	**0.004**
Awareness/Ever heard of PrEP	40 (65.6)	20 (80.0)	39 (81.2)	35 (79.5)	8 (72.7)	430 (83.7)	**0.029**
Ever discussed PrEP with provider	4 (6.6)	5 (20.0)	5 (10.4)	5 (11.4)	1 (9.1)	31 (6.0)	0.105
PrEP Use							
Ever	1 (1.6)	3 (10.7)	1 (2.0)	4 (8.9)	0 (0.0)	13 (2.4)	**0.027**
Current	0 (0.0)	2 (6.7)	1 (1.9)	2 (4.3)	0 (0.0)	4 (0.7)	**0.019**

Supplemental Table 2.5. Ratio of observed to expected relative joint effects (RJE) for All Outcomes, Transgender and Non-binary Participants, Washington State, 2019-2021

	Annual Income <$15,000[1]	Unstable Housing[1]	Uninsured[1]	No Regular Doctor/Provider[1]	HIV/STI Positivity[2]	Past Year HIV/STI Testing[1,3]	Ever Discussed PrEP with a Provider[4]	Current PrEP Use[4]
	RJE (95% CI)	RJE (95% CI)	RJE (95% CI)	RJE (95% CI)	RJE (95% CI)	RJE (95% CI)	RJE (95% CI)	RJE (95% CI)
White Trans Men	ref	ref	ref	ref	ref	ref	ref	ref
Trans Women								
Asian	0.64 (0.02, 1.26)	0.41 (-0.44, 1.27)	1.80 (-0.18, 3.78)	1.16 (0.23, 2.10)	0.66 (-0.45, 1.78)	1.06 (0.54, 1.57)	0.51 (0.12, 0.91)	1.26 (-0.43, 2.96)
Black	1.24 (0.41, 2.08)	1.93 (-0.23, 4.09)	1.49 (-0.91, 3.89)	2.81 (-0.53, 6.14)	2.01 (0.27, 3.76)	0.82 (0.51, 1.13)	1.04 (0.06, 2.01)	1.17 (-0.06, 2.40)
Latinx	1.20 (0.49, 1.90)	1.50 (-0.08, 3.08)	3.92 (-0.25, 8.08)	1.24 (0.23, 2.25)	3.06 (-0.70, 6.83)	1.69 (0.90, 2.48)	2.93 (-0.55, 6.41)	2.36 (-0.48, 5.20)
Native American/ Alaska Native	1.55 (-0.21, 3.32)	0.83 (-0.47, 2.13)	4.33 (-3.21, 11.9)	1.02 (-0.27, 2.31)	4.66 (-2.52, 11.8)	1.09 (0.43, 1.74)	1.42 (0.03, 2.80)	9.04 (-2.64, 20.7)
Native Hawaiian/ Pacific Islander	4.49 (-1.60, 10.6)	3.06 (0.14, 5.98)	13.8 (-9.04, 36.6)	0.90 (-0.34, 2.13)	6.83 (-1.57, 15.2)	3.79 (1.59, 6.00)	5.80 (-1.63, 13.2)	2.07 (-0.38, 4.52)
Non-binary AMAB								
Asian	3.05 (0.62, 5.49)	2.55 (-0.73, 5.83)	NA	0.17 (-0.13, 0.48)	1.55 (-0.20, 3.31)	0.89 (0.31, 1.46)	0.32 (-0.03, 0.66)	NA
Black	2.59 (0.13, 5.06)	9.09 (-3.97, 22.16)	1.08 (-1.17, 3.33)	1.84 (-0.89, 4.56)	0.84 (0.27, 1.42)	1.04 (0.67, 1.41)	1.16 (0.15, 2.18)	0.65 (-0.07, 1.38)
Latinx	1.55 (0.36, 2.74)	1.79 (-0.38, 3.96)	0.97 (-0.33, 2.28)	0.76 (0.09, 1.43)	1.40 (0.13, 2.68)	1.16 (0.57, 1.76)	1.73 (-0.92, 4.38)	2.40 (-0.15, 4.94)
Native American/ Alaska Native	3.12 (0.35, 5.89)	2.32 (-1.63, 6.27)	0.58 (-0.55, 1.72)	1.82 (-0.02, 3.66)	0.44 (-1.08, 1.97)	1.18 (0.49, 1.87)	1.02 (0.12, 1.93)	2.17 (-1.46, 5.79)
Native Hawaiian/ Pacific Islander	-5.73 (-21.9, 10.5)	15.19 (3.09, 27.3)	NA	NA	0.89 (-2.15, 3.93)	2.69 (0.07, 5.30)	NA	NA
Non-binary AFAB								
Asian	1.61 (0.64, 2.58)	-6.33 (-10.7, -1.98)	0.42 (-0.19, 1.03)	0.42 (0.07, 0.76)	3.83 (-1.68, 9.34)	1.13 (0.55, 1.71)	0.23 (-0.31, 0.77)	NA
Black	0.57 (0.08, 1.06)	2.16 (-1.79, 6.11)	NA	1.15 (-0.36, 2.66)	0.56 (-3.01, 4.12)	0.83 (0.38, 1.28)	1.14 (-0.95, 3.23)	0.60 (-4.92, 6.11)
Latinx	0.94 (0.39, 1.49)	4.41 (0.93, 7.89)	1.29 (-0.45, 3.04)	1.22 (0.30, 2.14)	0.89 (-2.21, 4.00)	1.04 (0.44, 1.63)	-2.84 (-7.67, 1.99)	0.99 (-2.96, 4.94)
Native American/ Alaska Native	2.65 (0.43, 4.86)	1.54 (-1.78, 4.87)	1.15 (-0.96, 3.26)	0.77 (-0.04, 1.58)	-2.34 (-17.2, 12.5)	0.71 (0.21, 1.21)	0.80 (-0.56, 2.16)	-1.90 (-20.8, 17.0)
Native Hawaiian/ Pacific Islander	41.59 (31.8, 51.4)	-22.46 (-32.2, -12.8)	NA	0.15 (-0.16, 0.45)	-6.99 (-46.4, 32.4)	329.05 (326.5, 331.6)	-1.11 (-9.12, 6.90)	NA

AFAB, assigned female at birth; AMAB, assigned male at birth; AR, attributable risk; CI, confidence interval

Measures all adjusted for participant age. The null value for the RJE is 1 and the reference for group is White transgender men.

[1] Excludes data collected from the Public Health-Seattle & King County Sexual Health Clinic, which did not collect these data.

[2] Defined as participants who self-reported having a bacterial STI (e.g. chlamydia, gonorrhea, syphilis) in the last 12 months or who self-reported being HIV positive.

[3] Restricted to sexually active participants who reported any oral, vaginal/front hole, or anal sex in the past 12 month.

[4] Restricted to participants who reported any vaginal/front hole or anal sex in the past 12 month.

Supplemental Table 2.6. Relative excess risk due to interaction (RERI) for All Outcomes, Transgender and Non-binary Participants, Washington State, 2019-2021

	Annual Income <$15,000[1]	**Unstable Housing[1]**	**Uninsured[1]**	**No Regular Doctor/Provider[1]**	**HIV/STI Positivity[2]**	**Past Year HIV/STI Testing[1,3]**	**Ever Discussed PrEP with a Provider[4]**	**Current PrEP Use[4]**
	RERI (95% CI)	RERI (95% CI)	RERI (95% CI)	RERI (95% CI)	RERI (95% CI)	RERI (95% CI)	RERI (95% CI)	RERI (95% CI)
White Trans Men	ref	ref	ref	ref	ref	ref	ref	ref
Trans Women								
Asian	-0.32 (-1.03, 0.39)	-0.97 (-2.99, 1.04)	3.40 (-2.62, 9.42)	0.28 (-1.19, 1.74)	-0.73 (-3.76, 2.30)	0.09 (-0.71, 0.90)	-1.79 (-4.16, 0.57)	1.06 (-4.77, 6.88)
Black	0.35 (-0.71, 1.42)	3.30 (-2.26, 8.86)	1.48 (-4.24, 7.20)	1.81 (0.21, 3.42)	5.74 (-1.00, 12.5)	-0.41 (-1.26, 0.43)	0.08 (-1.91, 2.06)	1.02 (-5.68, 7.73)
Latinx	0.25 (-0.59, 1.10)	1.20 (-1.95, 4.35)	9.47 (1.44, 17.49)	0.34 (-0.90, 1.59)	4.92 (-0.15, 9.99)	0.85 (0.26, 1.45)	1.20 (0.18, 2.23)	4.04 (-1.62, 9.71)
Native American/ Alaska Native	0.42 (-0.61, 1.45)	-0.65 (-6.18, 4.87)	8.93 (-0.82, 18.7)	0.04 (-1.95, 2.02)	3.38 (-1.37, 8.13)	0.15 (-0.89, 1.19)	0.82 (-1.40, 3.04)	10.31 (0.04, 20.6)
Native Hawaiian/ Pacific Islander	0.82 (0.22, 1.43)	3.36 (-0.35, 7.06)	8.56 (2.49, 14.6)	-0.34 (-4.88, 4.20)	5.41 (1.08, 9.75)	1.32 (0.90, 1.75)	1.95 (0.95, 2.95)	1.80 (-1.40, 4.99)
Non-binary AMAB								
Asian	0.80 (-1.15, 2.76)	1.00 (-4.35, 6.36)	-5.25 (-10.5, -0.05)	-1.92 (-3.27, -0.57)	3.21 (0.23, 6.18)	-0.20 (-1.20, 0.80)	-3.13 (-5.64, -0.62)	-6.11 (-11.9, -0.28)
Black	1.47 (-1.59, 4.52)	16.6 (-23.7, 56.9)	0.31 (-6.57, 7.18)	1.19 (-0.91, 3.29)	-1.43 (-6.86, 4.00)	0.10 (-0.72, 0.93)	0.48 (-1.61, 2.57)	-2.81 (-9.37, 3.76)
Latinx	0.44 (-0.97, 1.85)	1.24 (-3.53, 6.00)	-0.10 (-4.57, 4.37)	-0.45 (-1.60, 0.71)	2.66 (-0.22, 5.54)	0.22 (-0.43, 0.88)	0.97 (0.10, 1.85)	6.32 (0.61, 12.3)
Native American/ Alaska Native	0.67 (-1.03, 2.37)	3.67 (-9.22, 16.6)	-1.70 (-6.79, 3.40)	1.57 (-0.54, 3.69)	-2.44 (-4.01, -0.86)	0.32 (-0.72, 1.37)	0.07 (-1.81, 1.94)	4.16 (0.13, 8.18)
Native Hawaiian/ Pacific Islander	1.65 (-1.19, 4.50)	7.63 (-12.9, 28.2)	-1.51 (-2.85, -0.17)	-3.81 (-8.40, 0.77)	-0.47 (-3.10, 2.16)	0.96 (-0.10, 2.02)	-1.28 (-1.86, -0.69)	-3.86 (-6.21, -1.51)
Non-binary AFAB								
Asian	0.41 (-0.26, 1.09)	2.22 (-5.01, 9.46)	-2.40 (-7.18, 2.39)	-1.14 (-2.39, 0.11)	0.91 (-9.66, 11.5)	0.15 (-0.71, 1.01)	-2.01 (-4.73, 0.71)	-1.72 (-7.56, 4.11)
Black	-0.54 (-1.51, 0.43)	1.77 (-9.89, 13.4)	-2.69 (-7.45, 2.07)	0.17 (-1.19, 1.53)	-1.81 (-20.5, 16.8)	-0.30 (-1.34, 0.73)	0.16 (-3.45, 3.77)	-1.53 (-33.3, 30.2)
Latinx	-0.07 (-0.81, 0.67)	1.79 (-5.88, 9.45)	0.85 (-4.07, 5.76)	0.32 (-0.82, 1.47)	-0.13 (-6.78, 6.53)	0.03 (-0.71, 0.77)	1.08 (-1.00, 3.16)	-0.01 (-11.2, 11.1)
Native American/ Alaska Native	0.88 (-0.04, 1.80)	0.94 (-9.40, 11.3)	0.40 (-4.75, 5.56)	-0.39 (-1.98, 1.20)	2.24 (-10.6, 15.0)	-0.36 (-1.40, 0.69)	-0.21 (-2.69, 2.28)	2.19 (-22.4, 26.7)
Native Hawaiian/ Pacific Islander	1.49 (0.39, 2.59)	4.04 (-12.3, 20.3)	-0.47 (-1.81, 0.87)	-2.95 (-7.57, 1.68)	5.05 (-30.1, 40.3)	0.98 (-0.03, 1.99)	1.04 (-1.81, 3.90)	0.63 (-1.72, 2.99)

AFAB, assigned female at birth; AMAB, assigned male at birth; AR, attributable risk; CI, confidence interval

Measures all adjusted for participant age. The null value for the RERI is 0 and the reference for group is White transgender men.

[1] Excludes data collected from the Public Health-Seattle & King County Sexual Health Clinic, which did not collect these data.

[2] Defined as participants who self-reported having a bacterial STI (e.g. chlamydia, gonorrhea, syphilis) in the last 12 months or who self-reported being HIV positive.

[3] Restricted to sexually active participants who reported any oral, vaginal/front hole, or anal sex in the past 12 month.

[4] Restricted to participants who reported any vaginal/front hole or anal sex in the past 12 month.

Supplemental Table 2.7. Synergy Index (SI) for All Outcomes, Transgender and Non-binary Participants, Washington State, 2019-2021

	Annual Income <$15,000[1]	**Unstable Housing**[1]	**Uninsured**[1]	**No Regular Doctor/Provider**[1]	**HIV/STI Positivity**[2]	**Past Year HIV/STI Testing**[1,3]	**Ever Discussed PrEP with a Provider**[4]	**Current PrEP Use**[4]
	SI (95% CI)	SI (95% CI)	SI (95% CI)	SI (95% CI)	SI (95% CI)	SI (95% CI)	SI (95% CI)	SI (95% CI)
White Trans Men	ref	ref	ref	ref	ref	ref	ref	ref
Trans Women								
Asian	4.26 (-21.8, 30.3)	-0.47 (-3.17, 2.23)	2.05 (-0.85, 4.94)	1.38 (-1.14, 3.90)	0.37 (-1.43, 2.18)	1.14 (-0.25, 2.54)	0.33 (-0.13, 0.80)	1.35 (-1.03, 3.72)
Black	1.78 (-1.73, 5.28)	2.30 (-1.17, 5.77)	1.73 (-2.30, 5.76)	496.9 (-164311, 165305)	2.23 (-0.10, 4.56)	0.68 (0.19, 1.16)	1.07 (-0.84, 2.98)	1.21 (-0.30, 2.71)
Latinx	1.83 (-2.31, 5.98)	1.87 (-1.32, 5.05)	5.21 (-2.95, 13.4)	1.81 (-2.84, 6.47)	4.55 (-5.16, 14.3)	4.72 (-7.84, 17.3)	-2.19 (-8.29, 3.91)	3.05 (-2.46, 8.57)
Native American/ Alaska Native	-0.71 (-4.83, 3.42)	0.77 (-0.93, 2.47)	6.32 (-11.0, 23.7)	1.06 (-2.63, 4.76)	-42.4 (-839, 754)	1.21 (-0.52, 2.94)	1.85 (-1.61, 5.31)	37.53 (-212, 287)
Native Hawaiian/ Pacific Islander	-0.08 (-0.87, 0.71)	6.36 (-9.11, 21.8)	-24.84 (-139, 89.5)	0.85 (-0.83, 2.54)	-75.33 (-1626, 1475)	-1.52 (-3.12, 0.08)	-2.28 (-5.86, 1.31)	3.64 (-6.70, 13.9)
Non-binary AMAB								
Asian	-0.32 (-72.7, 72.0)	-1.82 (-10.9, 7.20)	-0.24 (-0.73, 0.26)	-0.46 (-2.47, 1.55)	1.67 (-2.48, 5.83)	0.73 (-0.64, 2.11)	0.13 (-0.34, 0.59)	-0.20 (-0.83, 0.43)
Black	-17.35 (-31.1, -3.65)	16.79 (-5.72, 39.3)	1.11 (-2.23, 4.44)	3.83 (-83505, 83512)	0.83 (0.19, 1.46)	1.08 (0.41, 1.75)	1.25 (-0.72, 3.22)	0.60 (-0.22, 1.43)
Latinx	-1.17 (-9.22, 6.87)	3.18 (-1.01, 7.37)	0.96 (-0.89, 2.82)	0.49 (-1.39, 2.36)	1.47 (-0.81, 3.76)	1.63 (-3.46, 6.71)	3.91 (-0.89, 8.70)	2.80 (-2.10, 7.69)
Native American/ Alaska Native	0.02 (-10.3, 10.3)	3.06 (-2.83, 8.95)	0.44 (-1.06, 1.94)	2.71 (-5.58, 11.0)	0.28 (-65.9, 66.5)	1.41 (-0.56, 3.39)	1.04 (-0.72, 2.79)	2.62 (-60.0, 65.3)
Native Hawaiian/ Pacific Islander	-0.33 (-4.34, 3.69)	-15.52 (-68.6, 37.5)	-1.96 (-14.19, 10.3)	-0.36 (-1.21, 0.50)	0.86 (-134, 135)	-1.23 (-3.52, 1.06)	-3.63 (-5.28, -1.97)	-0.35 (-5.40, 4.70)
Non-binary AFAB								
Asian	-0.26 (-24.2, 23.7)	-0.71 (-21.8, 20.4)	0.23 (-0.47, 0.94)	-0.20 (-1.39, 0.99)	-0.34 (-13.9, 13.2)	2.12 (0.37, 3.86)	-0.25 (-0.95, 0.44)	-1.38 (-2.01, -0.75)
Black	-1.17 (-2.77, 0.43)	4.36 (-1.97, 10.7)	-0.59 (-1.75, 0.56)	2.46 (-15298, 15303)	0.42 (-4.07, 4.90)	0.61 (-0.18, 1.41)	2.05 (-2.92, 7.02)	0.45 (-6.37, 7.28)
Latinx	0.26 (-1.87, 2.39)	-2.75 (-10.5, 5.02)	1.45 (-1.28, 4.17)	1.69 (-2.46, 5.84)	0.41 (-5.61, 6.42)	0.84 (-2.16, 3.84)	0.16 (-10.9, 11.2)	1.05 (-5.22, 7.31)
Native American/ Alaska Native	-0.91 (-11.6, 9.79)	2.29 (-2.76, 7.34)	1.23 (-2.31, 4.78)	0.43 (-1.06, 1.92)	-0.34 (-1978, 1978)	-0.54 (-1.48, 0.40)	-6.26 (-9.25, -3.26)	-0.25 (-287, 287)
Native Hawaiian/ Pacific Islander	-0.55 (-2.34, 1.24)	-2.44 (-47.5, 42.6)	1.87 (-10.4, 14.)	-0.20 (-0.81, 0.41)	-2.09 (-6504, 6500)	0.02 (-2.20, 2.23)	0.30 (-4.90, 5.50)	0.61 (-4.44, 5.67)

AFAB, assigned female at birth; AMAB, assigned male at birth; AR, attributable risk; CI, confidence interval

Measures all adjusted for participant age. The null value for the SI is 1 and the reference for group is White transgender men.

[1] Excludes data collected from the Public Health-Seattle & King County Sexual Health Clinic, which did not collect these data.

[2] Defined as participants who self-reported having a bacterial STI (e.g. chlamydia, gonorrhea, syphilis) in the last 12 months or who self-reported being HIV positive.

[3] Restricted to sexually active participants who reported any oral, vaginal/front hole, or anal sex in the past 12 month.

[4] Restricted to participants who reported any vaginal/front hole or anal sex in the past 12 month.

APPENDIX C: Methodology and Supplemental Materials for Chapter 3

i. Data Sources

We pooled cross-sectional data from six data sources available through Public Health – Seattle & King County (PHSKC): five included trans and non-binary participants, five included cis men, and three included cis women. Below is a summary of these data sources. All variables included in our analyses were assessed by self-report. Only three of the studies included laboratory-based HIV/STI testing (the PHSKC Sexual Health Clinic, the NHBS cycle among MSM, and NHBS/Project First), therefore we did not use laboratory-based HIV/STI prevalence in any analyses. These data sources are summarized in Supplemental Table 3.1

Supplemental Table 3.1. Summary of Data Sources from Washington State, 2017-2021

						Survey Items Included in our Analysis	
Data Source	**Year**	**Data Collection & Recruitment**	**Eligibility**	**Languages**	**Sample Size**	**Collected in All**	**Additional Variables**
PHSKC Sexual Health Clinic at Harborview Medical Center	2019-2020	Computerized intake survey for all patients	All patients with a new problem visit	English-speaking only	10,997 visits; 6,887 unique patients	Age, Race/ethnicity, Sexual orientation, Gender of partners (past year), HIV testing (ever and past year), HIV status, bacterial STI's diagnosed in the past year (chlamydia, gonorrhea, syphilis), current PrEP use, exchange sex, condomless sex (past year), number of sex partners (past year), Substance Use	Ever PrEP use, current ART use, Last viral load undetectable
PHSKC Pride Survey, 2019	2019	In-person paper survey, Sunday Pride Parade in Downtown Seattle and the Trans Pride Festival at Cal Anderson Park	Cisgender MSM and transgender people	English & Spanish	763		Ever PrEP use, STI testing (past year), PrEP awareness, Ever Discussed PrEP with a Provider, Reasons for not taking PrEP, Income, Unstable Housing, Health Insurance Status
PHSKC Pride Survey, 2020	2020	Online RedCap survey	All LGBTQ people	English & Spanish	1,612		Ever PrEP use, testing (past year), PrEP awareness, Ever Discussed PrEP with a Provider, Reasons for not taking PrEP, Income, Unstable Housing, Health Insurance Status
PHSKC Pride Survey, 2021	2021	Online RedCap survey	All LGBTQ people	English & Spanish	2,275		Ever PrEP use, STI testing (past year), PrEP awareness, Ever Discussed PrEP with a Provider, Reasons for not taking PrEP, Income, Unstable Housing, Health Insurance Status
NHBS, MSM Cycle	2017	In-person interview, venue-based recruitment	Cisgender MSM	English & Spanish	508		Current ART use, Last viral load undetectable, STI testing (past year), PrEP awareness, Ever Discussed PrEP with a Provider, Reasons for not taking PrEP, Income, Unstable Housing, Health Insurance Status
NHBS, Project FIRST	2019	In-person interview, chain-referral recruitment	Trans women and non-binary people AMAB	English & Spanish	117		Current ART use, Last viral load undetectable, STI testing (past year), PrEP awareness, Ever Discussed PrEP with a Provider, Reasons for not taking PrEP, Income, Unstable Housing, Health Insurance Status

MSM, men who have sex with men; NHBS, National HIV Behavioral Surveillance; PHSKC, Public-Health Seattle & King County

Supplemental Table 3.2 provides a summary of study participants by data source. The 2019 Pride Survey, which was conducted in-person during June Pride events in Seattle, had a much higher proportion of young participants age <24 (55%). All Pride Surveys also had much higher proportion of White participants. Both National HIV Behavioral Surveillance surveys and the Sexual Health Clinic has the highest prevalence of self-reported bacterial STI diagnoses and current PrEP use.

Supplemental Table 3.2. Summary of Demographic and HIV/STI related variables by Data Source, Washington State, 2017-2021

	PHSKC Sexual Health Clinic	PHSKC Pride Survey, 2019	PHSKC Pride Survey, 2020	PHSKC Pride Survey, 2021	NHBS, MSM Cycle	NHBS, Project FIRST	p-value
N	6886	763	1612	2275	508	117	
Age							
24 or younger	1050 (15.2)	421 (55.2)	246 (15.3)	410 (18.0)	36 (7.1)	16 (13.7)	**<0.001**
25 and older	5830 (84.7)	341 (44.7)	1303 (80.8)	1755 (77.1)	472 (92.9)	101 (86.3)	
Gender							
Cisgender Man	5405 (78.5)	480 (62.9)	533 (33.1)	614 (27.0)	508 (100.0)	0 (0.0)	
Cisgender Woman	1275 (18.5)	0 (0.0)	681 (42.3)	940 (41.3)	0 (0.0)	0 (0.0)	
Non-binary AFAB	50 (0.7)	97 (12.7)	185 (11.5)	394 (17.3)	0 (0.0)	0 (0.0)	**<0.001**
Non-binary AMAB	74 (1.1)	45 (5.9)	37 (2.3)	78 (3.4)	0 (0.0)	8 (6.8)	
Transgender Man	30 (0.4)	71 (9.3)	81 (5.0)	135 (5.9)	0 (0.0)	0 (0.0)	
Transgender Woman	52 (0.8)	61 (8.0)	69 (4.3)	72 (3.2)	0 (0.0)	109 (93.2)	
Race/ethnicity							
Asian	700 (10.2)	72 (9.4)	143 (8.9)	234 (10.3)	43 (8.5)	18 (15.4)	0.151
Black	1258 (18.3)	43 (5.6)	62 (3.8)	80 (3.5)	66 (13.0)	21 (17.9)	**<0.001**
Hispanic/Latinx	811 (11.8)	103 (13.5)	196 (12.4)	235 (10.3)	90 (17.7)	25 (21.4)	**<0.001**
Native American/ Alaska Native	152 (2.2)	38 (5.0)	49 (3.0)	89 (3.9)	42 (8.3)	8 (6.8)	**<0.001**
Native Hawaiian/ Pacific Islander	98 (1.4)	14 (1.8)	23 (1.4)	33 (1.5)	13 (2.6)	41 (35.0)	**<0.001**
White	4176 (60.7)	611 (80.1)	1356 (84.1)	1829 (80.4)	397 (78.1)	37 (31.6)	**<0.001**
Sexual Orientation							
Straight	2902 (46.8)	25 (3.3)	11 (0.7)	17 (0.7)	5 (1.0)	50 (42.7)	**<0.001**
Gay	2258 (36.4)	410 (53.7)	609 (37.8)	693 (30.5)	428 (84.3)	14 (12.0)	**<0.001**
Bisexual	608 (9.8)	127 (16.6)	434 (26.9)	620 (27.3)	75 (14.8)	18 (15.4)	**<0.001**
Queer	229 (3.7)	155 (20.3)	521 (32.3)	657 (28.9)		29 (24.8)	**<0.001**
Lesbian	22 (0.4)	23 (12.5)	313 (19.4)	456 (20.0)		5 (4.3)	**<0.001**
Pansexual	164 (2.6)	54 (29.3)	242 (15.0)	302 (13.3)		14 (12.0)	**<0.001**
HIV Positive	337 (4.9)	42 (5.5)	77 (4.8)	80 (3.5)	92 (18.1)	22 (18.8)	**<0.001**
Bacterial STI (last year)	1565 (22.7)	52 (12.7)	67 (12.7)	36 (8.7)	122 (32.4)	12 (18.2)	**<0.001**
HIV Testing							
Ever	5083 (73.8)	621 (81.4)	1132 (70.2)	1488 (65.4)	497 (97.8)	104 (88.9)	**<0.001**
In the last year	2572 (37.4)	389 (51.0)	508 (31.5)	438 (32.7)	362 (71.3)	71 (60.7)	**<0.001**
STI Testing (last year)		407 (53.3)	536 (33.3)	418 (18.4)	374 (73.6)	63 (53.8)	**<0.001**
PrEP Use							
Ever Used	1387 (55.9)	122 (16.9)	191 (12.4)	186 (8.5)			**<0.001**
Current Use	1047 (16.0)	85 (11.8)	106 (6.9)	109 (5.0)	137 (32.9)	16 (16.8)	**<0.001**

MSM, men who have sex with men; NHBS, National HIV Behavioral Surveillance; PHSKC, Public-Health Seattle & King County

ii. Gender of Sex Partners by Sexual Orientation

The following tables (Supplemental Tables 3.3-3.6) report the gender of partners for TNB participants stratified by sexual orientation. The 2019, 2020, and 2021 Pride Surveys allowed participants to select more than one sexual orientation, therefore, some participants are included in multiple table columns.

Supplemental Table 3.3. Transgender Women's Reported Sex Partners in the Last Year, Stratified by Sexual Orientation, Pooled Data for Washington State, 2019-2021

	Transgender Women						
	Straight	Gay	Lesbian	Bisexual	Pansexual	Queer	p-value
N (%)	85 (23.4)	34 (9.4)	85 (23.4)	79 (21.8)	54 (14.9)	92 (25.3)	
Gender of Sex Partners (n, %)							
Trans men	1 (1.2)	3 (8.8)	7 (8.2)	10 (12.7)	11 (20.4)	12 (13.0)	**0.009**
Trans women	1 (1.2)	6 (17.6)	29 (34.1)	20 (25.3)	21 (38.9)	21 (22.8)	**<0.001**
Non-binary	1 (2.9)	2 (9.1)	24 (30.0)	15 (23.8)	16 (38.1)	23 (34.3)	**0.002**
Non-binary AFAB[1]	0 (0.0)	1 (5.6)	13 (16.2)	8 (14.5)	10 (23.8)	12 (19.7)	0.054
Non-binary AMAB[1]	1 (2.9)	1 (5.6)	13 (16.2)	6 (10.9)	7 (16.7)	12 (19.7)	0.203
Cisgender men	68 (80.0)	21 (61.8)	7 (8.2)	35 (44.3)	19 (35.2)	40 (43.5)	**<0.001**
Cisgender women	3 (3.5)	3 (8.8)	26 (30.6)	19 (24.1)	15 (27.8)	24 (26.1)	**<0.001**

AMAB = assigned male at birth, AFAB = assigned female at birth

[1] Information about sex assigned a birth of non-binary partners was only collected at the Sexual Health Clinic, 2020 Pride Survey, and 2021 Pride Survey. Not all participants responded to this question.

Supplemental Table 3.4. Transgender Men's Reported Sex Partners in the Last Year, Stratified by Sexual Orientation, Pooled Data for Washington State, 2019-2021

	Transgender Men					
	Straight	Gay	Bisexual	Pansexual	Queer	p-value
N (%)	17 (5.4)	78 (24.6)	93 (29.3)	43 (13.6)	158 (49.8)	
Gender of Sex Partners (n, %)						
Trans men	0 (0.0)	18 (23.1)	20 (21.5)	6 (14.0)	35 (22.2)	0.185
Trans women	0 (0.0)	9 (11.5)	10 (10.8)	9 (20.9)	14 (8.9)	0.121
Non-binary	0 (0.0)	18 (23.1)	17 (18.3)	14 (32.6)	48 (30.4)	**0.019**
Non-binary AFAB[1]	0 (0.0)	11 (15.9)	10 (12.2)	8 (18.6)	34 (22.8)	0.099
Non-binary AMAB[1]	0 (0.0)	11 (15.9)	7 (8.5)	10 (23.3)	16 (10.7)	0.057
Cisgender men	5 (29.4)	38 (48.7)	31 (33.3)	20 (46.5)	55 (34.8)	0.128
Cisgender women	9 (52.9)	10 (12.8)	26 (28.0)	4 (9.3)	52 (32.9)	**<0.001**

AMAB = assigned male at birth, AFAB = assigned female at birth

No transgender men identified as lesbian.

[1] Information about sex assigned a birth of non-binary partners was only collected at the Sexual Health Clinic, 2020 Pride Survey, and 2021 Pride Survey. Not all participants responded to this question.

Supplemental Table 3.5. Non-binary People Assigned Male at Birth's Reported Sex Partners in the Last Year, Stratified by Sexual Orientation, Pooled Data for Washington State, 2019-2021

	Non-binary People Assigned Male at Birth						
	Straight	Gay	Lesbian	Bisexual	Pansexual	Queer	p-value
N (%)	1 (0.1)	56 (7.7)	107 (14.7)	167 (23)	201 (27.7)	440 (60.6)	
Gender of Sex Partners (n, %)							
Trans men	0 (0.0)	6 (10.7)	4 (3.7)	15 (9.0)	20 (10.0)	51 (11.6)	0.279
Trans women	0 (0.0)	7 (12.5)	11 (10.3)	30 (18.0)	33 (16.4)	51 (11.6)	0.236
Non-binary	0 (0.0)	21 (37.5)	25 (23.4)	49 (29.3)	68 (33.8)	174 (39.5)	**0.019**
Non-binary AFAB[1]	0 (0.0)	15 (28.8)	23 (21.5)	30 (18.4)	44 (21.9)	119 (27.9)	0.154
Non-binary AMAB[1]	0 (0.0)	8 (15.4)	8 (7.5)	27 (16.6)	46 (22.9)	73 (17.1)	**0.033**
Cisgender men	1 (100.0)	11 (19.6)	1 (0.9)	75 (44.9)	107 (53.2)	154 (35.0)	**<0.001**
Cisgender women	0 (0.0)	14 (25.0)	40 (37.4)	26 (15.6)	45 (22.4)	125 (28.4)	**0.001**

AMAB = assigned male at birth, AFAB = assigned female at birth

[1] Information about sex assigned a birth of non-binary partners was only collected at the Sexual Health Clinic, 2020 Pride Survey, and 2021 Pride Survey. Not all participants responded to this question.

Supplemental Table 3.6. Non-binary People Assigned Female at Birth's Reported Sex Partners in the Last Year, Stratified by Sexual Orientation, Pooled Data for Washington State, 2019-2021

	Non-binary People Assigned Female at Birth						
	Straight	Gay	Lesbian	Bisexual	Pansexual	Queer	p-value
N (%)	4 (1.7)	77 (31.8)	4 (1.7)	39 (16.1)	46 (19)	128 (52.9)	
Gender of Sex Partners (n, %)							
Trans men	0 (0.0)	0 (0.0)	1 (25.0)	4 (10.3)	8 (17.4)	16 (12.5)	**0.016**
Trans women	0 (0.0)	4 (5.2)	3 (75.0)	10 (25.6)	8 (17.4)	14 (10.9)	**<0.001**
Non-binary	0 (0.0)	25 (33.3)	3 (75.0)	18 (48.6)	17 (38.6)	68 (54.8)	**0.012**
Non-binary AFAB[1]	0 (0.0)	3 (4.2)	3 (75.0)	13 (40.6)	13 (29.5)	29 (24.6)	**<0.001**
Non-binary AMAB[1]	0 (0.0)	21 (29.6)	3 (75.0)	9 (28.1)	8 (18.2)	48 (40.7)	**0.019**
Cisgender men	0 (0.0)	62 (80.5)	0 (0.0)	15 (38.5)	12 (26.1)	84 (65.6)	**<0.001**
Cisgender women	4 (100.0)	3 (3.9)	0 (0.0)	16 (41.0)	25 (54.3)	29 (22.7)	**<0.001**

AMAB = assigned male at birth, AFAB = assigned female at birth

[1] Information about sex assigned a birth of non-binary partners was only collected at the Sexual Health Clinic, 2020 Pride Survey, and 2021 Pride Survey. Not all participants responded to this question.

iii. Additional Correlates of Having a TNB Partner

The following tables (Supplemental Tables 3.7-3.9) present Poisson regression results exploring demographic and behavioral factors associated with having a TNB partner in the last year, adjusted for data source.

Supplemental Table 3.7. Bivariate Regression Models of Demographic and Behavioral Factors Associated with having a Trans Woman Sex Partner in the last year, Pooled Data for Washington State, 2017-2021

	Factors Associated With Having 1 or more Trans Women Partners					
	Cis Men Participants		Cis Women Participants		Transgender & Non-binary Participants	
	aPR (95% CI)	p-value	aPR (95% CI)	p-value	aPR (95% CI)	p-value
N	7540		2896		1648	
Age						
24 or younger	1.07 (0.66, 1.74)	0.793	0.98 (0.49, 1.97)	0.960	1.29 (0.96, 1.73)	0.095
25 and older	[ref]		[ref]		[ref]	
Race/ethnicity						
Asian	0.5 (0.24, 1.03)	0.059	1.15 (0.49, 2.72)	0.748	0.85 (0.5, 1.44)	0.547
Black	0.76 (0.45, 1.3)	0.317	NA		0.81 (0.44, 1.52)	0.514
Hispanic/Latinx	0.64 (0.33, 1.23)	0.179	0.24 (0.03, 1.84)	0.169	1.08 (0.66, 1.78)	0.757
Native American/Alaska Native	1.38 (0.56, 3.43)	0.487	1.44 (0.35, 5.94)	0.617	0.84 (0.43, 1.65)	0.617
Native Hawaiian/Pacific Islander	2.1 (0.77, 5.7)	0.146	NA		0.47 (0.16, 1.36)	0.162
White	[ref]		[ref]		[ref]	
Sexual Orientation						
Straight/Heterosexual	**0.52 (0.32, 0.83)**	**0.006**	*NA*		**0.05 (0.01, 0.38)**	**0.003**
Gay	**0.07 (0.04, 0.12)**	**<0.001**	0.32 (0.04, 2.31)	0.256	0.78 (0.52, 1.18)	0.248
Bisexual	**8.45 (6.02, 11.9)**	**<0.001**	1.03 (0.58, 1.84)	0.909	**1.87 (1.39, 2.51)**	**<0.001**
Queer	**4.42 (2.61, 7.49)**	**<0.001**	**3.11 (1.73, 5.61)**	**<0.001**	0.91 (0.69, 1.2)	0.508
Lesbian	*NA*		0.69 (0.35, 1.36)	0.285	**2.11 (1.49, 2.98)**	**<0.001**
Pansexual	**11.6 (7.25, 18.6)**	**<0.001**	**2.75 (1.48, 5.11)**	**0.001**	**1.91 (1.43, 2.56)**	**<0.001**
Income[1]						
Less than $15,000	0.88 (0.33, 2.32)	0.794	2.27 (0.88, 5.9)	0.091	**1.77 (1.16, 2.7)**	**0.008**
$15,000 to $30,000	1.89 (0.94, 3.79)	0.074	**3.34 (1.36, 8.21)**	**0.009**	**1.57 (1.00, 2.47)**	**0.048**
$30,000 to $50,000	1.13 (0.54, 2.37)	0.740	**2.81 (1.18, 6.66)**	**0.019**	1.11 (0.66, 1.85)	0.700
more than $50,000	[ref]		[ref]		[ref]	
Unstable housing/homeless[1]	**4.39 (2.09, 9.19)**	**<0.001**	1.17 (0.16, 8.5)	0.878	**1.88 (1.17, 3.02)**	**0.009**
Has medical insurance[1]	**0.46 (0.21, 0.99)**	**0.046**	1.08 (0.26, 4.46)	0.919	1.32 (0.73, 2.38)	0.359
Any condomless vaginal/front hole or anal sex[2]	1.23 (0.8, 1.9)	0.339	0.33 (0.1, 1.04)	0.057	0.81 (0.52, 1.27)	0.361
10 or more sex partners[2]	**1.85 (1.28, 2.68)**	**0.001**	**6.76 (3.26, 14)**	**<0.001**	**3.85 (2.77, 5.36)**	**<0.001**
Exchanged sex for money or drugs[2]	2.08 (0.91, 4.74)	0.083	**7.82 (2.99, 20.47)**	**<0.001**	**2.84 (1.89, 4.25)**	**<0.001**
Substance use[2]						
Injection drug use	1.33 (0.69, 2.53)	0.394	0.67 (0.09, 5.16)	0.703	1.29 (0.47, 3.53)	0.617
Methamphetamine	1.44 (0.86, 2.42)	0.162	NA		1.51 (0.78, 2.92)	0.219
Cocaine/crack	1.55 (0.98, 2.47)	0.063	1.04 (0.24, 4.4)	0.963	1.44 (0.92, 2.26)	0.109
Heroin	0.83 (0.31, 2.26)	0.719	NA		0.9 (0.22, 3.67)	0.886
Poppers	1.4 (0.97, 2.02)	0.069	2.04 (0.28, 14.78)	0.481	**2.06 (1.42, 2.99)**	**<0.001**

aPR, adjusted prevalence ratio; CI, confidence interval; PrEP, pre-exposure prophylaxis; STI, sexually transmitted infection.
All bivariate Poisson regression models are adjusted for the data source.
[1] These data are not collected at the Sexual Health Clinic. These data are only from participants in the Pride Surveys and NHBS.
[2] In the last year

Supplemental Table 3.8. Bivariate Regression Models of Demographic and Behavioral Factors Associated with having a Trans Man Sex Partner in the last year, Pooled Data for Washington State, 2017-2021

	Factors Associated With Having 1 or more Trans Men Partners					
	Cis Men Participants		Cis Women Participants		Transgender & Non-binary Participants	
	aPR (95% CI)	p-value	aPR (95% CI)	p-value	aPR (95% CI)	p-value
N	7540		2896		1648	
Age						
24 or younger	1.05 (0.72, 1.53)	0.797	1.61 (0.93, 2.79)	0.089	1.23 (0.9, 1.69)	0.197
25 and older	[ref]		[ref]		[ref]	
Race/ethnicity						
Asian	0.68 (0.41, 1.14)	0.144	0.67 (0.24, 1.85)	0.437	0.92 (0.53, 1.6)	0.763
Black	0.93 (0.61, 1.4)	0.716	0.65 (0.19, 2.16)	0.479	1.29 (0.73, 2.26)	0.377
Hispanic/Latinx	0.62 (0.39, 1.01)	0.052	0.42 (0.13, 1.34)	0.143	0.56 (0.29, 1.08)	0.081
Native American/Alaska Native	**1.97 (1.11, 3.51)**	**0.021**	0.55 (0.08, 3.98)	0.554	1.68 (0.98, 2.87)	0.059
Native Hawaiian/Pacific Islander	0.82 (0.26, 2.58)	0.738	*NA*		0.89 (0.27, 2.96)	0.847
White	[ref]		[ref]		[ref]	
Sexual Orientation						
Straight/Heterosexual	**0.17 (0.09, 0.3)**	**<0.001**	*NA*	0.975	**0.09 (0.01, 0.63)**	**0.015**
Gay	**0.42 (0.32, 0.57)**	**<0.001**	0.53 (0.13, 2.21)	0.386	0.95 (0.63, 1.43)	0.810
Bisexual	**3.65 (2.72, 4.9)**	**<0.001**	0.87 (0.51, 1.47)	0.594	**1.32 (0.95, 1.85)**	**0.099**
Queer	**3.98 (2.63, 6.04)**	**<0.001**	**6.89 (3.93, 12.1)**	**<0.001**	**1.58 (1.17, 2.12)**	**0.003**
Lesbian	*NA*		**0.31 (0.15, 0.67)**	**0.003**	0.56 (0.31, 1.01)	0.054
Pansexual	**6.9 (4.34, 10.96)**	**<0.001**	**2.44 (1.38, 4.31)**	**0.002**	1.2 (0.85, 1.69)	0.302
Income[1]						
Less than $15,000	1.48 (0.88, 2.48)	0.141	1.2 (0.57, 2.56)	0.632	1.36 (0.84, 2.18)	0.209
$15,000 to $30,000	**1.69 (1.05, 2.72)**	**0.031**	0.85 (0.34, 2.12)	0.734	1.56 (0.96, 2.52)	0.073
$30,000 to $50,000	0.79 (0.45, 1.38)	0.408	1.21 (0.59, 2.45)	0.606	1.57 (0.94, 2.6)	0.082
more than $50,000	[ref]		[ref]		[ref]	
Unstable housing/homeless[1]	**2.03 (1.14, 3.61)**	**0.017**	**5.02 (1.99, 12.64)**	**0.001**	1.2 (0.66, 2.2)	0.543
Has medical insurance[1]	0.94 (0.49, 1.8)	0.848	2.69 (0.37, 19.45)	0.328	0.75 (0.44, 1.26)	0.277
Any condomless vaginal/front hole or anal sex[2]	**4.17 (2.61, 6.67)**	**<0.001**	0.56 (0.16, 1.98)	0.368	1.23 (0.77, 1.95)	0.382
10 or more sex partners[2]	**3.98 (2.97, 5.34)**	**<0.001**	**5.36 (2.63, 10.94)**	**<0.001**	**3.01 (2.09, 4.33)**	**<0.001**
Exchanged sex for money or drugs[2]	**3.14 (1.9, 5.18)**	**<0.001**	**4.81 (1.7, 13.66)**	**0.003**	**2.24 (1.41, 3.57)**	**0.001**
Substance use[2]						
Injection drug use	0.90 (0.49, 1.66)	0.745	0.55 (0.07, 4.14)	0.559	1.31 (0.41, 4.15)	0.648
Methamphetamine	1.17 (0.76, 1.82)	0.474	0.43 (0.06, 3.31)	0.421	0.57 (0.18, 1.79)	0.333
Cocaine/crack	**1.95 (1.39, 2.73)**	**<0.001**	1.29 (0.39, 4.25)	0.676	1.21 (0.73, 2.02)	0.459
Heroin	1.02 (0.48, 2.18)	0.951	0.73 (0.09, 5.55)	0.757	*NA*	
Poppers	**2.51 (1.92, 3.27)**	**<0.001**	**5 (1.56, 15.97)**	**0.007**	**1.78 (1.18, 2.69)**	**0.006**

aPR, adjusted prevalence ratio; CI, confidence interval; PrEP, pre-exposure prophylaxis; STI, sexually transmitted infection.
All bivariate Poisson regression models are adjusted for the data source.
[1] These data are not collected at the Sexual Health Clinic. These data are only from participants in the Pride Surveys and NHBS.
[2] In the last year

Supplemental Table 3.9. Bivariate Regression Models of Demographic and Behavioral Factors Associated with having a Non-binary Sex Partner in the last year, Pooled Data for Washington State, 2017-2021

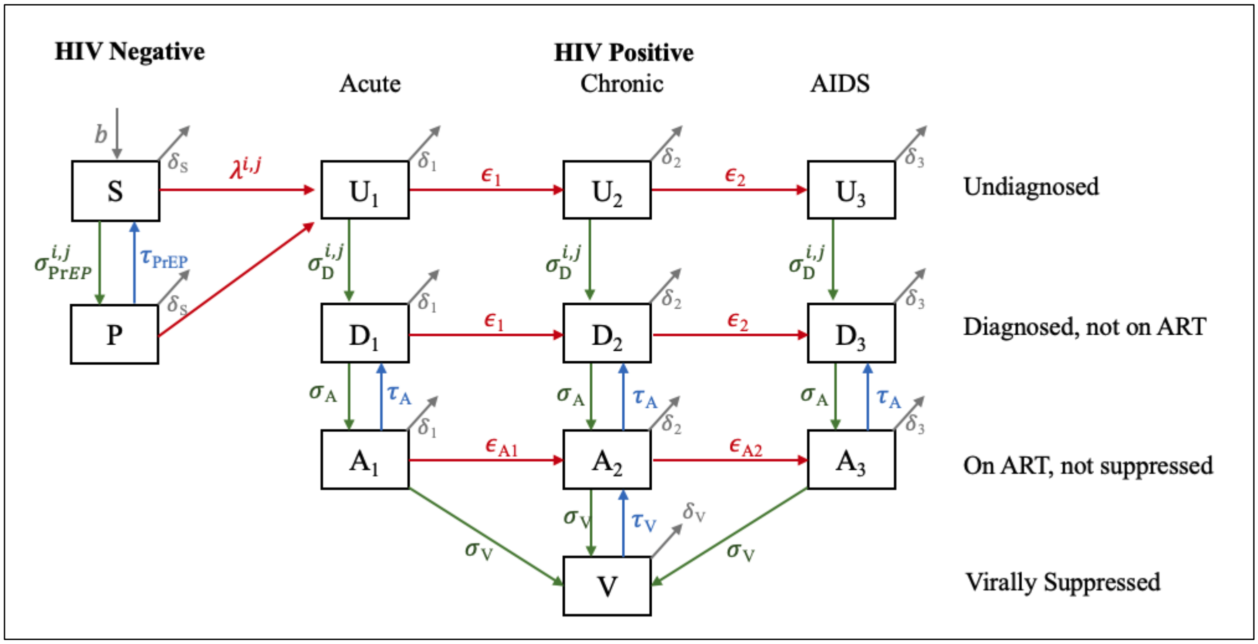
	Factors Associated With Having 1 or more Non-binary Partners					
	Cis Men Participants		Cis Women Participants		Transgender & Non-binary Participants	
	aPR (95% CI)	p-value	aPR (95% CI)	p-value	aPR (95% CI)	p-value
N	7540		2896		1648	
Age						
24 or younger	0.98 (0.7, 1.37)	0.898	1.16 (0.8, 1.66)	0.434	0.95 (0.77, 1.17)	0.623
25 and older	[ref]		[ref]		[ref]	
Race/ethnicity						
Asian	0.76 (0.5, 1.16)	0.204	1.01 (0.6, 1.7)	0.978	0.87 (0.6, 1.25)	0.446
Black	1.17 (0.81, 1.68)	0.402	1.06 (0.58, 1.96)	0.844	1.25 (0.85, 1.82)	0.257
Hispanic/Latinx	0.87 (0.58, 1.31)	0.507	1.02 (0.58, 1.8)	0.948	0.85 (0.59, 1.21)	0.366
Native American/Alaska Native	**1.84 (1.1, 3.08)**	**0.021**	**1.96 (1.03, 3.72)**	**0.040**	0.94 (0.61, 1.45)	0.770
Native Hawaiian/Pacific Islander	0.86 (0.32, 2.3)	0.758	1 (0.24, 4.09)	0.999	1.32 (0.67, 2.61)	0.426
White	[ref]		[ref]		[ref]	
Sexual Orientation						
Straight/Heterosexual	**0.18 (0.1, 0.31)**	**<0.001**	**0.02 (0, 0.12)**	**<0.001**	**0.04 (0.01, 0.29)**	**0.001**
Gay	**0.38 (0.29, 0.49)**	**<0.001**	0.86 (0.44, 1.69)	0.655	0.95 (0.73, 1.24)	0.723
Bisexual	**2.93 (2.24, 3.84)**	**<0.001**	0.82 (0.6, 1.13)	0.220	0.97 (0.77, 1.22)	0.805
Queer	**4.78 (3.52, 6.47)**	**<0.001**	**2.72 (1.99, 3.71)**	**<0.001**	**2.09 (1.72, 2.54)**	**<0.001**
Lesbian	*NA*		0.82 (0.58, 1.15)	0.245	0.98 (0.73, 1.31)	0.897
Pansexual	**6.81 (4.72, 9.83)**	**<0.001**	**2.1 (1.48, 2.97)**	**<0.001**	**1.21 (0.98, 1.5)**	**0.078**
Income[1]						
Less than $15,000	1.19 (0.76, 1.87)	0.449	1.27 (0.83, 1.96)	0.273	**0.70 (0.53, 0.92)**	**0.011**
$15,000 to $30,000	1.36 (0.9, 2.04)	0.143	1.17 (0.73, 1.88)	0.504	0.91 (0.69, 1.2)	0.486
$30,000 to $50,000	1 (0.67, 1.49)	0.989	1.04 (0.67, 1.61)	0.864	0.9 (0.67, 1.21)	0.468
more than $50,000	[ref]		[ref]		[ref]	
Unstable housing/homeless[1]	1.69 (0.94, 3.03)	0.079	1.91 (0.84, 4.31)	0.122	1.41 (0.98, 2.04)	0.065
Has medical insurance[1]	0.65 (0.41, 1.04)	0.072	1.11 (0.52, 2.37)	0.792	1.11 (0.75, 1.66)	0.596
Any condomless vaginal/front hole or anal sex[2]	**2.03 (1.38, 2.98)**	**<0.001**	0.54 (0.24, 1.23)	0.144	1.11 (0.82, 1.51)	0.482
10 or more sex partners[2]	**3.28 (2.55, 4.21)**	**<0.001**	**4.11 (2.57, 6.58)**	**<0.001**	**2.82 (2.23, 3.56)**	**<0.001**
Exchanged sex for money or drugs[2]	**3.14 (2, 4.92)**	**<0.001**	**3.75 (1.82, 7.75)**	**<0.001**	**1.98 (1.44, 2.73)**	**<0.001**
Substance use[2]						
Injection drug use	0.68 (0.35, 1.33)	0.261	0.47 (0.11, 1.97)	0.304	0.76 (0.28, 2.05)	0.587
Methamphetamine	0.99 (0.63, 1.55)	0.964	0.19 (0.03, 1.36)	0.098	0.69 (0.34, 1.4)	0.309
Cocaine/crack	1.38 (0.97, 1.96)	0.073	1.39 (0.67, 2.87)	0.379	**1.74 (1.29, 2.34)**	**<0.001**
Heroin	**0.13 (0.02, 0.96)**	**0.045**	*NA*		0.29 (0.04, 2.09)	0.220
Poppers	**2.09 (1.65, 2.64)**	**<0.001**	**2.9 (1.19, 7.07)**	**0.019**	**1.93 (1.49, 2.51)**	**<0.001**

aPR, adjusted prevalence ratio; CI, confidence interval; PrEP, pre-exposure prophylaxis; STI, sexually transmitted infection.
All bivariate Poisson regression models are adjusted for the data source.
[1] These data are not collected at the Sexual Health Clinic. These data are only from participants in the Pride Surveys and NHBS.
[2] In the last year

APPENDIX D: Methodology and Supplemental Materials for Chapter 4

i. Detailed Model Description

Our model is described by a system of 168 ordinary differential equations (12 compartments for disease stage and engagement in care x 7 demographic groups x 2 groups defined by higher/lower likelihood of HIV acquisition).



We used the following indexing to represent:

- Demographic group $i \in \{1$ (trans women), 2 (trans men), 3 (non-binary AMAB), 4 (non-binary AFAB), 5 (sexual minority cis men), 6 (sexual minority cis women), 7 (heterosexual cis men)$\}$
- Higher/lower likelihood of HIV acquisition $j \in \{1$ (lower), 2 (higher)$\}$
- Disease stage $k \in \{1$ (acute), 2 (chronic), 3 (AIDS)$\}$

The simulated population is stratified into the following compartment (see Figure 1):

- $S^{i,j}$: HIV-negative (i.e. susceptible) population <u>not</u> currently using PrEP in demographic group i and strata j
- $P^{i,j}$: HIV-negative (i.e. susceptible) population currently using PrEP in demographic group i and strata j
- $U_k^{i,j}$: Undiagnosed HIV-positive population in demographic group i, strata j, and disease stage k
- $D_k^{i,j}$: Diagnosed HIV-positive population <u>not</u> on ART in demographic group i, strata j, and disease stage k

- $A_k^{i,j}$: HIV-positive population on ART but not virally suppressed in demographic group i, strata j, and disease stage k
- $V^{i,j}$: HIV-positive population who are virally suppressed in demographic group i and strata j
- $N^{i,j}$: Total population in demographic group i and strata j

Model parameters include:

- ϵ: progression along disease stages (horizontal arrows in Figure 1)
  - ϵ_1: acute to chronic among those not on ART
  - ϵ_2: chronic to AIDS among those not on ART
  - ϵ_{A1}: acute to chronic among those on ART
  - ϵ_{A2}: chronic to AIDS among those on ART
- σ: progression through engagement with care (vertical arrows)
  - $\sigma_{\mathrm{PrEP}}^{i,j}$: rate of PrEP initiation in demographic group i and strata j
  - $\sigma_{\mathrm{D}}^{i,j}$: rate of diagnosis via HIV testing in demographic group i and strata j
  - σ_{A}^{i}: rate of ART initiation in demographic group i
  - σ_{V}: rate of viral suppression
- τ: drop rate/discontinuation from engagement with care
  - $\tau_{\mathrm{PrEP}}^{i,j}$: PrEP discontinuation rate in demographic group i and strata j
  - τ_{A}^{i}: ART discontinuation rate in demographic group i
  - τ_{V}: drop from virally suppression
- b: “birth” rate of entering population
- δ: death rates
  - δ_{S}: death rate among HIV-negative population
  - δ_{k}: death rate among HIV-positive population by disease stage k
  - δ_{V}: death rate among virally suppressed HIV-positive population
- α_{PrEP}: PrEP efficacy per sex act
- $\alpha_{condoms}$: condom efficacy per sex act
- α_{ART}: ART efficacy in reducing infectiousness per sex act when not virally suppressed
- $m^{ij,uv}$: probability of demographic group i and strata j partnering with demographic group u and strata v (from mixing matrix)
- $\eta^{i,j}$: average annual number of sex partners for demographic group i and strata j
- n^{ij}: average number of sex acts per partnership per year for demographic group i and strata j
- c^{ij}: proportion of sex acts using a condom for demographic group i and strata j
- β: HIV transmission probability per sex act
- β_k: multiplier for increased per sex act transmission probability by disease stage k
- θ_k: multiplier for reduced sexual activity with AIDS

We define the force of infection, $\lambda^{i,j}$, for demographic group i and strata j as:

$$\lambda^{i,j} = \eta^{i,j}\, n^{ij}\, (1 - c^{ij}\alpha_{condoms}) \sum_{u,v} m^{ij,uv} \times \left(\sum_{k=1,2,3} \theta_k \beta_k \beta \frac{\left(\mathrm{U}_\mathrm{k}^{\mathrm{u},v} + \mathrm{D}_\mathrm{k}^{\mathrm{u},v}\right)}{N^{u,v}} + (1-\alpha_{ART})\, \beta_k \beta \frac{\mathrm{A}_\mathrm{k}^{\mathrm{u},v}}{N^{u,v}} \right)$$

The model is defined by the following equations:

- HIV Negative:

$$\frac{dS^{i,j}}{dt} = bN^{i,j} + \left(-\sigma_{PrEP}^{i,j} - \lambda^{i,j} - \delta_S\right)S^{i,j} + \tau_{PrEP}P^{i,j}$$

$$\frac{dP^{i,j}}{dt} = \left(-\tau_{PrEP} - (1-\alpha_{PrEP})\lambda^{i,j} - \delta_S\right)P^{i,j} + \sigma_{PrEP}^{i,j}S^{i,j}$$

- Acute HIV:

$$\frac{dU_1^{i,j}}{dt} = \left(-\sigma_D^{i,j} - \epsilon_1 - \delta_1\right)U_1^{i,j} + \lambda^{i,j}S^{i,j} + (1-\alpha_{PrEP})\lambda^{i,j}P^{i,j}$$

$$\frac{\mathrm{d}D_1^{\mathrm{i,j}}}{\mathrm{dt}} = \left(-\sigma_\mathrm{A}^i - \epsilon_1 - \delta_1\right)\mathrm{D}_1^{\mathrm{i,j}} + \sigma_D^{i,j}\mathrm{U}_1^{\mathrm{i,j}} + \tau_\mathrm{A}^i\mathrm{A}_1^{\mathrm{i,j}}$$

$$\frac{\mathrm{d}A_1^{\mathrm{i,j}}}{\mathrm{dt}} = \left(-\sigma_V - \epsilon_{A1} - \tau_\mathrm{A}^i - \delta_{A1}\right)\mathrm{A}_1^{\mathrm{i,j}} + \sigma_\mathrm{A}^i\mathrm{D}_1^{\mathrm{i,j}}$$

- Chronic HIV:

$$\frac{\mathrm{dU}_2^{\mathrm{i,j}}}{\mathrm{dt}} = \left(-\sigma_D^{i,j} - \epsilon_2 - \delta_2\right)\mathrm{U}_2^{\mathrm{i,j}} + \epsilon_1\mathrm{U}_1^{\mathrm{i,j}}$$

$$\frac{\mathrm{d}D_2^{\mathrm{i,j}}}{\mathrm{dt}} = \left(-\sigma_\mathrm{A}^i - \epsilon_2 - \delta_2\right)\mathrm{D}_2^{\mathrm{i,j}} + \sigma_D^{i,j}\mathrm{U}_2^{\mathrm{i,j}} + \tau_\mathrm{A}^i\mathrm{A}_2^{\mathrm{i,j}} + \epsilon_1\mathrm{D}_1^{\mathrm{i,j}}$$

$$\frac{\mathrm{d}A_2^{\mathrm{i,j}}}{\mathrm{dt}} = \left(-\sigma_V - \epsilon_{A2} - \tau_\mathrm{A}^i - \delta_{A2}\right)\mathrm{A}_2^{\mathrm{i,j}} + \sigma_\mathrm{A}^i\mathrm{D}_2^{\mathrm{i,j}} + \tau_V V^{i,j} + \epsilon_{A1}\mathrm{A}_1^{\mathrm{i,j}}$$

- AIDS:

$$\frac{\mathrm{dU}_3^{\mathrm{i,j}}}{\mathrm{dt}} = \left(-\sigma_D^{i,j} - \delta_3\right)\mathrm{U}_3^{\mathrm{i,j}} + \epsilon_2\mathrm{U}_2^{\mathrm{i,j}}$$

$$\frac{\mathrm{d}D_3^{\mathrm{i,j}}}{\mathrm{dt}} = \left(-\sigma_\mathrm{A}^i - \delta_3\right)\mathrm{D}_3^{\mathrm{i,j}} + \sigma_D^{i,j}\mathrm{U}_3^{\mathrm{i,j}} + \tau_\mathrm{A}^i\mathrm{A}_3^{\mathrm{i,j}} + \epsilon_2\mathrm{D}_2^{\mathrm{i,j}}$$

$$\frac{\mathrm{d}A_3^{\mathrm{i,j}}}{\mathrm{dt}} = \left(-\sigma_V - \tau_\mathrm{A}^i - \delta_{A3}\right)\mathrm{A}_3^{\mathrm{i,j}} + \sigma_\mathrm{A}^i\mathrm{D}_3^{\mathrm{i,j}} + \epsilon_{A2}\mathrm{A}_2^{\mathrm{i,j}}$$

- Virally Suppressed:

$$\frac{dV^{i,j}}{\mathrm{dt}} = (-\tau_V - \delta_V)V^{i,j} + \sigma_V(\mathrm{A}_1^{\mathrm{i,j}} + \mathrm{A}_2^{\mathrm{i,j}} + \mathrm{A}_3^{\mathrm{i,j}})$$

ii. Parameter Values

Supplemental Table 4.1. Fixed Parameters			
Description	**Demographic Group**	**Value**	**Source**
Population Size	Trans Women	124,246	Back-calculated based on HIV prevalence reported in TransPop study and CDC HIV surveillance Data.[7] Note these are much lower than recent estimates of the size of the transgender population in the US.[6]
Population Size	Trans Men	35250	
Population Size	Non-binary AMAB	4,453	
Population Size	Non-binary AFAB		
Population Size	Sexual Minority Cis Men	4,000,000	3.5% of US male adults age 18-64[194]
Population Size	Sexual Minority Cis Women	4,000,000	3.5% of US female adults age 18-64[194]
Population Size	Heterosexual Cis Men	200,000	0.2% of heterosexual cis men age 18-64[194] and Chapter 3
Fraction of Population with higher likelihood of HIV acquisition	Trans Women	13.7%	BRFSS 2016-20 data
Fraction of Population with higher likelihood of HIV acquisition	Trans Men	8.4%	BRFSS 2016-20 data
Fraction of Population with higher likelihood of HIV acquisition	Non-binary AMAB	23.1%	BRFSS 2016-20 data
Fraction of Population with higher likelihood of HIV acquisition	Non-binary AFAB	14.1%	BRFSS 2016-20 data
Fraction of Population with higher likelihood of HIV acquisition	Sexual Minority Cis Men	29.8%	BRFSS 2016-20 data
Fraction of Population with higher likelihood of HIV acquisition	Sexual Minority Cis Women	16.0%	BRFSS 2016-20 data
Fraction of Population with higher likelihood of HIV acquisition	Heterosexual Cis Men	29.8%	BRFSS 2016-20 data
"Birth" rate	All Groups	0.012	Average US birth rate in 2014-2019
Death rate among HIV-negative	All Groups	0.0025	Average US Death rate, age 15-64
Death rate among acute HIV	All Groups	0.012	195,196
Death rate among chronic HIV	All Groups	0.012	195,196
Death rate among AIDS	All Groups	0.022	195
Death rate among virally suppressed	All Groups	0.0025	Assume same as HIV-negative individuals
Initial Conditions, HIV prevalence (%)	Transgender Women	6.5%	7
Initial Conditions, HIV prevalence (%)	Transgender Men	0.8%	7
Initial Conditions, HIV prevalence (%)	Non-binary AMAB	5.1%	7

Initial Conditions, HIV prevalence (%)	Non-binary AFAB	0.2%	3
Initial Conditions, HIV prevalence (N)	Transgender Women	8076	197
Initial Conditions, HIV prevalence (N)	Transgender Men	282	197
Initial Conditions, HIV prevalence (N)	Non-binary	118	197
Initial Conditions, HIV prevalence (N)	Sexual Minority Cis Men	470000	197
Initial Conditions, Undiagnosed Fraction	All Groups	15%	198,199
Initial Conditions, Proportion of Diagnoses at Acute stage	All Groups	5%	197
Initial Conditions, Proportion of Diagnoses at Chronic stage	All Groups	75%	197
Initial Conditions, Proportion of Diagnoses at AIDS	All Groups	20%	197
Initial Conditions, Proportion of Diagnosed People on ART	All TNB	70%	3,17,79,200
Initial Conditions, Proportion of Diagnosed People on ART	Sexual Minority Cis Men	74%	201
Initial Conditions, Proportion of Diagnosed People on ART	Sexual Minority Cis Women	73%	201
Initial Conditions, Proportion of Diagnosed People on ART	Heterosexual Cis Men	68%	201
Initial Conditions, Proportion of Diagnosed People who are Virally Suppressed	All TNB	60%	13,17,79,200,201
Initial Conditions, Proportion of Diagnosed People who are Virally Suppressed	Sexual Minority Cis Men	60%	201
Initial Conditions, Proportion of Diagnosed People who are Virally Suppressed	Sexual Minority Cis Women	55%	201
Initial Conditions, Proportion of Diagnosed People who are Virally Suppressed	Heterosexual Cis Men	55%	201
Multiplier for increased per act transmission risk for acute stage	All groups	10	202–204
Multiplier for increased per act transmission risk for AIDS	All groups	5	202–204

Supplemental Table 4.2. Calibration Parameters			
Description	**Demographic Group**	**Range**	**Source**
HIV transmission probability per sex act (for vaginal sex or insertive anal sex)	All groups	0.001 – 0.01	205,206
Disease Progression from acute to chronic among individuals not on ART	Same for all groups	1/0.25 – 1/0.125 (equivalent to a duration of 1.8-3 months)	
Disease Progression from chronic to AIDS among individuals not on ART	Same for all groups	1/10 – 1/6 (equivalent to a duration of 6-10 years)	
Disease Progression from acute to chronic among individuals on ART	Same for all groups	1/0.25 – 1/0.125 (equivalent to a duration of 1.5-3 months)	
Disease Progression from chronic to AIDS among individuals on ART	Same for all groups	1/40 – 1/10 (equivalent to a duration of 10-40 years)	
PrEP initiation	Varies by demographic group	0.001 – 0.25	
ART initiation	Varies by demographic group	1-3	
Rate of Viral Suppression	Same for all groups	1-10	
PrEP discontinuation	Varies by demographic group	0.001 – 0.1	
ART discontinuation	Varies by demographic group	0.1 – 0.3	
Drop rate for viral suppression	Same for all groups	0.01 – 0.1	
Annual HIV Testing/ Diagnosis	Trans Women, higher likelihood of HIV acquisition	36.8% - 50.6%	BRFSS 2016-20 data
Annual HIV Testing/ Diagnosis	Trans Men, higher likelihood of HIV acquisition	30.1% - 49.1%	BRFSS 2016-20 data
Annual HIV Testing/ Diagnosis	Non-binary AMAB, higher likelihood of HIV acquisition	31.7% - 46.4%	BRFSS 2016-20 data
Annual HIV Testing/ Diagnosis	Non-binary AFAB, higher likelihood of HIV acquisition	31.7% - 46.4%	BRFSS 2016-20 data
Annual HIV Testing/ Diagnosis	Sexual Minority Cis Men, higher likelihood of HIV acquisition	56.5% - 61.8%	BRFSS 2016-20 data
Annual HIV Testing/ Diagnosis	Sexual Minority Cis Women, higher likelihood of HIV acquisition	37.8% - 44.8%	BRFSS 2016-20 data
Annual HIV Testing/ Diagnosis	Heterosexual Cis Men, higher likelihood of HIV acquisition	26.0% - 28.8%	BRFSS 2016-20 data
Annual HIV Testing/ Diagnosis	Trans Women, lower likelihood of HIV acquisition	9.7% - 13.2%	BRFSS 2016-20 data

Annual HIV Testing/ Diagnosis	Trans Men, lower likelihood of HIV acquisition	9.5% - 13.2%	BRFSS 2016-20 data
Annual HIV Testing/ Diagnosis	Non-binary AMAB, lower likelihood of HIV acquisition	10.1% - 14.9%	BRFSS 2016-20 data
Annual HIV Testing/ Diagnosis	Non-binary AFAB, lower likelihood of HIV acquisition	10.1% - 14.9%	BRFSS 2016-20 data
Annual HIV Testing/ Diagnosis	Sexual Minority Cis Men, lower likelihood of HIV acquisition	20.5% - 23.5%	BRFSS 2016-20 data
Annual HIV Testing/ Diagnosis	Sexual Minority Cis Women, lower likelihood of HIV acquisition	17.0% - 19.4%	BRFSS 2016-20 data
Annual HIV Testing/ Diagnosis	Heterosexual Cis Men, lower likelihood of HIV acquisition	8.7% - 9.2%	BRFSS 2016-20 data
Reduction in transmissibility associated with being on ART but not virally suppressed	Same for all groups	50% - 70%	
Efficacy of condoms in preventing HIV transmission	Same for all groups	70% – 80%	
Efficacy of PrEP preventing HIV transmission	Same for all groups	90% – 95%	
Multiplier for reduced sexual activity during AIDS		0.2 – 0.5	
Annual number of partners	Lower likelihood of HIV acquisition (Varies by demographic group)	1 –2	
Annual number of partners	Higher likelihood of HIV acquisition (Varies by demographic group)	30 – 50	5
Number of sex acts per partnership per year	Lower likelihood of HIV acquisition (Varies by demographic group)	20 – 40	
Number of sex acts per partnership per year	Higher likelihood of HIV acquisition (Varies by demographic group)	1 – 5	

Proportion of sex acts using a condom	Lower likelihood of HIV acquisition (Varies by demographic group)	0.4 – 0.7	5,60
Proportion of sex acts using a condom	Higher likelihood of HIV acquisition (Varies by demographic group)	0.4 – 0.7	5,60
Assortative mixing by higher/lower likelihood of HIV acquisition	Same for all groups	0.7 – 0.95	