FLORIDA INTERNATIONAL UNIVERSITY

Miami, Florida

IDENTIFYING GAY NEIGHBORHOODS AND ESTIMATION OF THE SIZE OF THE MEN WHO HAVE SEX WITH MEN POPULATION IN FLORIDA WHO WOULD BENEFIT FROM PRE-EXPOSURE PROPHYLAXIS

A dissertation submitted in partial fulfillment of the

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by

Daniel Mauck

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To: Dean Tomás R. Guilarte
Robert Stempel College of Public Health and Social Work

This dissertation, written by Daniel Mauck, and entitled Identifying Gay Neighborhoods and Estimation of the Size of the Men Who Have Sex with Men Population in Florida Who Would Benefit from Pre-exposure Prophylaxis, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this dissertation and recommend that it be approved.

_____
Kristopher Fennie

_____
Gladys Ibañez

_____
Eric Fenkl

_____
Mary Jo Trepka, Major Professor

Date of Defense: June 26, 2019

The dissertation of Daniel Mauck is approved.

_____
Dean Tomás R. Guilarte
Robert Stempel College of Public Health and Social Work

_____
Andrés G. Gil
Vice President for Research and Economic Development
and Dean of the University Graduate School

Florida International University, 2019

DEDICATION

This dissertation is dedicated to my late mother, and to family and friends who supported and encouraged me during this academic journey.

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ABSTRACT OF THE DISSERTATION

IDENTIFYING GAY NEIGHBORHOODS AND ESTIMATION OF THE SIZE OF THE MEN WHO HAVE SEX WITH MEN POPULATION IN FLORIDA WHO WOULD BENEFIT FROM PRE-EXPOSURE PROPHYLAXIS

by

Daniel Mauck

Florida International University, 2019

Miami, Florida

Professor Mary Jo Trepka, Major Professor

Given the potential benefit of pre-exposure prophylaxis (PrEP) among men who have sex with men (MSM) at risk for human immunodeficiency virus (HIV), it would be useful to assess the size of the at-risk population and their geographic distribution to target PrEP and other prevention programs efficiently. In 2017, Florida ranked third for HIV diagnosis rates in the US, and 63% of those who received a new HIV diagnosis in Florida were MSM. The purpose of this dissertation was to 1) summarize population-based methods to estimate the size of the population of MSM, 2) identify gay neighborhoods using latent class analysis (LCA), and 3) estimate the size of the MSM population in Florida.

A systematic review of population-based methods to estimate the size of the MSM population was conducted. Twenty-eight studies met inclusion criteria. Sixteen studies were conducted in the US, five in European countries, two in Canada, three in

Australia, one in Israel, and one in Kenya. Men who have sex with men made up 0.03–6.4% of men among all studies and ranged from 3.8–6.4% in the US, 7,000–39,100 in Canada, 0.03–6.5% in European countries, and 127,947–182,624 in Australia.

Latent class analysis was used to identify gay neighborhoods in Florida. Data at the ZIP code level was drawn from the 2011–2015 ACS, website lists of gay bars and neighborhoods, and the Florida Department of Health's HIV surveillance system. A two-class model was selected. About 9% of the ZIP code data were in class two (gay neighborhoods). Cohen's kappa coefficient was used to examine agreement between the classification of ZIP codes from LCA and gay neighborhoods from websites. Fair agreement was found (0.2501).

Three methods were used to estimate the MSM population in Florida with high-risk behaviors that would indicate eligibility for PrEP use. The resulting three estimates were averaged, and the number of MSM living with HIV infection in each ZIP code was subtracted. The average MSM estimate in ZIP codes ranged from 1–2,184 men (1.5–22.9%). The presumed HIV-negative MSM estimate in ZIP codes ranged from 1–1,346 men (0.02–12.7%). Indications for PrEP were highest for MSM with more than one sex partner in the past year and lowest when the estimate was multiplied by 24.7% (percent of MSM with PrEP indications from other studies).

In conclusion, there is no widely accepted method to estimate the size of the MSM population, and estimates vary substantially based on the method used. Therefore, it would be prudent to consider a range of estimates in planning HIV prevention efforts.

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ABBREVIATIONS AND ACRONYMS

MSM	Men who have sex with men
HIV	Human immunodeficiency virus
LCA	Latent class analysis
ZIP	Zone improvement plan
PrEP	Pre-exposure prophylaxis
eHARS	enhanced HIV/AIDS reporting system
US	United States
ACS	American Community Survey
STI	Sexually transmitted infection
PRISMA-P	Preferred Reporting Items for Systematic review and Meta-Analysis Protocols
PROSPERO	International Prospective Register of Systematic Reviews
MSA	Metropolitan statistical area
NHBS	National HIV Behavioral Surveillance
YBMSM	Young black men who have sex with men
SRN	Social Risk and Network Assessment
EMIS	European MSM Internet Survey
ECDC	European Centre for Disease Prevention and Control
AIDS	Acquired Immune Deficiency Syndrome
IDU	Injection drug user
CHM	Canada Health Monitor
NSFG	National Survey of Family Growth
NHANES	National Health and Nutrition Examination Survey
ASHR	Australian Study of Health and Relationships
KABaSTI	Knowledge, Attitudes and Behaviour as to Sexually Transmitted Infections

GMA	Gay Men and AIDS survey
CCHS	Canadian Community Health Survey
NATSAL	National Survey of Sexual Attitudes and Lifestyles
YRBS	Youth Risk Behavior Survey
LBG	Lesbian, gay, or bisexual
ONS	Office of National Statistics
NCHS	National Center for Health Statistics
SSMP	Same sex male partner
SSM	Same sex male

Introduction

Male-to-male sexual contact accounted for 66.6% of new human immunodeficiency virus (HIV) diagnoses in 2017 and 72% of existing HIV infections at the end of 2016 in the United States (US) (CDC, 2018). Florida ranked third in the US for HIV diagnosis rates in 2017 (CDC, 2018). The Miami-Fort Lauderdale-West Palm Beach, FL metropolitan statistical area (MSA) had 35.3 HIV diagnoses per 100,000 population in 2017, the highest rate in the US (CDC, 2018). The Orlando-Kissimmee-Sanford, FL MSA ranked second in the US with 28.6 HIV diagnoses per 100,000 population while the Jacksonville, FL MSA was ranked seventh (23.5 per 100,000) (CDC, 2018). Men who have sex with men (MSM) can be at high risk for HIV, but accurate estimates of this population are hard to obtain because census systems typically do not ask about sexual behavior or orientation, surveys are challenged with concerns about stigma, and measurement issues related to different domains of sexual orientation (e.g. behavior, identity, or attraction) (Wesson et al., 2017; Purcell et al., 2012).

Several methods have been developed to estimate the size of hard-to-reach populations (Wesson et al., 2017). Among these, population-based methods to estimate the size of the MSM population use the size of the general population combined with data on HIV prevalence among MSM from surveillance systems, the percentages of men reporting same-sex experience, attraction, or identity from large, national health surveys, or male-male unmarried partner household data from the US Census Bureau to produce estimates of MSM (Wesson et al., 2017; Grey et al., 2016).

It is difficult to estimate the size of this population directly due to stigma. Therefore, researchers have examined data about behavioral characteristics, attraction, or identity. Based on the specific calculation method, there may be men missing from the estimate if they have sex with men but do not consider themselves gay or bisexual. Many MSM identify as gay or bisexual, but not all (Grey et al., 2016). Other methods have been used to estimate population sizes and include capture-recapture, network scale-up, wisdom of the crowds, multiplier, and Delphi (Wesson et al., 2017; Abdul-Quader et al., 2014).

The National HIV/AIDS Strategy strives to increase HIV prevention efforts in communities with high rates of HIV transmission and recommends focusing on high-risk populations, such as MSM (Office of National AIDS Policy, 2015). Strategies have been adopted by MSM to reduce the risk of HIV transmission (van den Boom et al., 2014). Serosorting, where MSM engage in unprotected anal intercourse with other MSM of the same HIV status, is common (van den Boom et al., 2014). This strategy is not without flaws; both partners must accurately know their status, disclose their status honestly, and should be tested frequently to be sure they have not acquired HIV (van den Boom et al., 2014). Condoms are another strategy to reduce the risk of HIV transmission. A study among MSM in San Francisco found that the consistent use of condoms decreased from 36.8% in 2004 to 18.3% in 2014 (Chen et al., 2016). Concordant and discordant condom use decreased among HIV-positive and HIV-negative MSM in a study using data from the National HIV Behavioral Surveillance system (Paz-Bailey et al., 2016). In a study with data from the American Men's

Internet survey, HIV-positive participants were more likely to have had condomless sex in the past twelve months and condomless sex with a serodiscordant or unknown status partner compared to HIV-negative MSM (Zlotorzynska et al., 2019).

Tailoring HIV prevention strategies to whether MSM live in gay neighborhood or not or rural versus urban areas could be another strategy to reduce HIV transmission. Gay neighborhoods can be defined as areas within a city that foster a sense of community for gay men due to a higher proportion of homes occupied by gay men and businesses owned by or supportive of gay men (Buttram & Kurtz, 2013). The first distinct gay neighborhoods emerged after World War II when discharged members of the military settled in port cities (Spring, 2013). Bars in gay neighborhoods established social networks that made sexual minorities visible to one another and fostered a sense of community (Ghaziani, 2014). In the 1970s, researchers reported that large cities gave rise to cultural and social institutions that form the basis of gay neighborhoods (Buttram & Kurtz, 2013). The US Census Bureau has collected data on same-sex unmarried partners since 1990, which has provided data for the study of gay neighborhoods (Compton & Baumle, 2012).

There are mixed findings in the literature about risk or protective factors associated with gay neighborhood residence. Some studies show that gay neighborhoods facilitate HIV sexual risk behaviors and drug use, while others show that they are protective for health (Buttram & Kurtz, 2013; Kelly et al., 2012; Carpiano et al., 2011; Frye et al., 2010). A study conducted in South Florida found that elevated rates of unprotected anal intercourse, methamphetamine use, and

reduced levels of engagement in social activities were risk factors associated with living in a gay neighborhood (Buttram & Kurtz, 2013). Gay neighborhood residence was defined as residing in one of five zone improvement plan (ZIP) codes that constitute the Wilton Manors area (Buttram & Kurtz, 2013). In a study conducted in New York City, the use of drugs to enhance sexual experiences was more common among men who lived in gay neighborhoods compared to men who did not (aOR=2.08, 95% confidence interval [CI]=1.11–3.90) (Kelly et al., 2012). Gay neighborhoods were defined using the percentage of male-male unmarried partner households and social mapping (Kelly et al., 2012). A second study conducted in New York City found higher odds of drug use among individuals who lived in gay neighborhoods, had networks composed mainly of gay men, and had increased socialization with other gay men (Carpiano et al., 2011). Gay neighborhoods were defined using the percentage of male-male unmarried partner households from census data and social mapping (Carpiano et al., 2011). Alternatively, another study conducted in New York City found that neighborhood gay presence (percent of male-male unmarried partner households) was associated with consistently using condoms during insertive (adjusted odds ratio [aOR]=1.3, 95% CI=1.0–1.6) and receptive anal intercourse (aOR=1.4, 95% CI=1.1–1.6) (Frye et al., 2010).

More recently, gay individuals may be choosing to live outside of historically gay neighborhoods (Spring, 2013). Historically gay neighborhoods appear to be de-concentrating as sexual minorities disperse across cities (Ghaziani, 2014). Based on the 2010 Census, fewer same-sex partners lived in historically gay neighborhoods in

2010 than in 2000 or 1990 (Ghaziani, 2014). Many studies have used the percent of male-male unmarried partner households obtained from the census (Kelly et al., 2012; Carpiano et al., 2011; Frye et al., 2010). This is self-reported, and misclassification has been noted (O'Connell & Feliz, 2012). It is likely that 7% of opposite-sex households were misclassified as same-sex unmarried partner households in the 2010 ACS (Krieder & Lofquist, 2015). None of the articles that have classified neighborhoods as gay using census data has established a validated cutoff for identifying gay neighborhoods (Frye et al., 2010; Buttram & Kurtz, 2013; Kelly et al., 2012; Carpiano et al., 2011).

Rural MSM may face barriers to accessing HIV prevention services (Hubach et al., 2017). Men who have sex with men who live in rural areas may have different experiences with HIV prevention and treatment than those who live in urban areas. Recent literature has found that MSM in rural areas have difficulty finding prevention programs and HIV testing sites, do not believe HIV is a local threat, and do not engage in HIV risk reduction (Hubach et al., 2017). Additionally, MSM that live in rural areas may have limited access to HIV prevention services, such as pre-exposure prophylaxis (PrEP) (Hubach et al., 2017).

Pre-exposure prophylaxis is a newer strategy to reduce the risk of HIV infection and involves the regular use of antiretroviral drugs by a person whose HIV status is negative to reduce the risk of HIV transmission from sexual contact with a person who is living with HIV or someone of unknown HIV status (Jayakumaran et al., 2016). Pre-exposure prophylaxis was approved by the US Food and Drug

Administration in 2012 for populations at high risk of acquiring HIV (Garcia & Harris, 2017). Pre-exposure prophylaxis has been shown to reduce new HIV infections by over 90% among MSM in randomized trials, and the Centers for Disease Control and Prevention (CDC) recommends its use among populations at high risk of HIV infection (Hoots et al., 2014; Kelley et al., 2015). Levels of uptake and awareness of PrEP among MSM are low, which represents a missed opportunity for HIV prevention efforts (Elsesser et al., 2016). If 40% of HIV-negative MSM were taking PrEP, it is estimated that about 25% of new infections could be prevented over a 10-year period (Kelley et al., 2015). Increasing the PrEP coverage to 80% could prevent 40% of new infections over 10 years (Kelley et al., 2015). In 2014, the US Public Health Services released guidelines for PrEP use among high-risk groups (US Public Health Service, 2014). Given the large potential benefit of widespread PrEP use among MSM at high risk for HIV infection, it would be useful to assess the size of the at-risk population and their geographic distribution so that prevention programs can be targeted efficiently.

In conclusion, there is no widely accepted method to estimate the size of the MSM population, and estimates vary substantially based on the method used. Therefore, it would be prudent to consider a range of estimates in planning HIV prevention efforts

This dissertation aimed to summarize population-based methods to estimate the size of the population of men that have sex with men, identify gay neighborhoods using the percent of male-male unmarried partners, the density of gay bars, and HIV

prevalence data for MSM using latent class analysis (LCA), and estimate the size of the MSM population in Florida by zone improvement plan (ZIP) code, rural/urban residence, county, and indications for pre-exposure prophylaxis (PrEP) use. This dissertation contributes to the field specifically by estimating the size and location of the MSM population, which could help with HIV prevention planning for this high-risk group. Secondly, it contributes to the field generally, by examining and comparing various proposed methods for estimating size and location of MSM populations; this will help to advance he methods and understanding on how to enumerate and estimate populations that are difficult to define.

References

Abdul-Quader AS, Baughman AL, Hladik W. Estimating the size of key populations: current status and future possibilities. *Current Opin HIV AIDS*. 2014;9(2):107–114.

Buttram ME, Kurtz SP. Risk and Protective Factors Associated With Gay Neighborhood Residence. *Am J Mens Health*. 2013;7(2):110-118.

Carpiano RM, Kelly BC, Easterbrook A, Parsons JT. Community and drug use among gay men: The role of neighborhoods and networks. *J Health Soc Behav*. 2011;52(1):74–90.

Centers for Disease Control and Prevention. HIV Surveillance Report, 2017; vol. 29. 2018. Available at: https://www.cdc.gov/hiv/pdf/library/reports/surveillance/cdc-hiv-surveillance-report-2017-vol-29.pdf

Chen Y, Snowden JM, McFarland W, Raymond HF. Pre-exposure Prophylaxis (PrEP) Use, Seroadaptation, and Sexual Behavior Among Men Who Have Sex with Men, San Francisco, 2004–2014. *AIDS Behav*. 2016;20(12):2791–2797.

Compton DR, Baumle AK. Beyond the Castro: The role of demographics in the selection of gay and lesbian enclaves. *J Homosex*. 2012;59(10):1327-1355.

Elsesser SA, Oldenburg CE, Biello KB, et al. Seasons of risk: anticipated behavior on vacation and interest in episodic antiretroviral pre-exposure prophylaxis (PrEP) among a large national sample of US men who have sex with men (MSM). *AIDS Behav.* 2016;20(7):1400–1407.

Frye V, Koblin B, Chin J, et al. Neighborhood-level correlates of consistent condom use among men who have sex with men: A multi-level analysis. *AIDS Behav*. 2010;14(4):974–985.

Garcia M, Harris AL. PrEP awareness and decision-making for Latino MSM in San Antonio, Texas. *PLOS One*. 2017;12(9):e0184014.

Ghaziani A. Measuring urban sexual cultures. *Theory Soc*. 2014;43(3-4):371–393.

Grey JA, Bernstein KT, Sullivan PS, et al. Estimating the population sizes of men who have sex with men in US states and counties using data from the American Community Survey. *JMIR Public Health Surveill*. 2016;2(1):e14.

Hoots BE, Finlayson T, Nerlander L, et al. Willingness to take, use of, and indications for pre-exposure prophylaxis among men who have sex with men—20 US cities, 2014. *Clin Infect Dis.* 2016;63(5):672–677.

Hubach RD, Currin JM, Sanders CA, et al. Barriers to access and adoption of pre-exposure prophylaxis for the prevention of HIV among men who have sex with men (MSM) in a relatively rural state. *AIDS Educ Prev*. 2017:29(4):315–359.

Jayakumaran JS, Aaron E, Gracely EJ, et al. Knowledge, attitudes, and acceptability of pre-exposure prophylaxis among individuals living with HIV at an urban HIV clinic. *PLOS One*. 2016;11(2):e0145670.

Kelly BC, Carpiano RM, Easterbrook A, Parsons JT. Sex and the community: The implications of neighbourhoods and social networks for sexual risk behaviours among urban gay men. *Sociol Health Illn*. 2012;34(7):1085–1102.

Kelley CF, Kahle E, Siegler A, et al. Applying a PrEP continuum of care for men who have sex with men in Atlanta, Georgia. *Clin Infect Dis*. 2015;61(10):1590–1597.

Krieder RM, Lofquist DA. Matching survey data with administrative records to evaluate reports of same-sex married couple households. Bureau of the Census. 2015. Available at: https://www.census.gov/library/working-papers/2015/demo/SEHSD-WP2014-36.html

Office of National AIDS Policy. National HIV/AIDS Strategy Updated to 2020. 1–65; 2015. Available at: https://files.hiv.gov/s3fs-public/nhas-update.pdf.

O'Connell M, Feliz, S. Same-sex Couple Household Statistics from the 2010 Census. Bureau of the Census. 2011.. Available at: https://www.census.gov/library/working-papers/2011/demo/SEHSD-WP2011-26.html.

Paz-Bailey G, Mendoza MCB, Finlayson T, et al. Trends in condom use among MSM in the United States: the role of antiretroviral therapy and seroadaptive strategies. *AIDS*. 2016;30(12):1985–1990.

Purcell DW, Johnson CH, Lansky A, et al. Estimating the population size of men who have sex with men in the United States to obtain HIV and syphilis rates. *Open AIDS J.* 2012;6:98–107.

Spring AL. Declining segregation of same-sex partners: Evidence from Census 2000 and 2010. *Popul Res Policy Rev*. 2013;32(5):687-716.

Wesson P, Reingold A, McFarland W. Theoretical and empirical comparisons of methods to estimate the size of hard-to-reach populations: a systematic review. *AIDS Behav.* 2017;21(7):2188–2206.

van den Boom, W, Konings R, Davidovich U, et al. Is serosorting effective in reducing the risk of HIV-infection among men who have sex with men with casual sex partners? *J Acquir Immune Defic Syndr*. 2014;65(3):375–379.

Zlotorzynska M, Sullivan P, Sanchez T. The Annual American Men's Internet Survey of Behaviors of Men Who Have Sex With Men in the United States: 2016 Key Indicators Report. *JMIR Public Health Surveill.* 2019;5(1):e11313.

Manuscript 1

Population-based methods for estimating the number of men who have sex with men: A systematic review

Abstract

The objective of this systematic review was to summarize population-based methods (i.e., methods that used representative data from populations) for estimating the population size of men who have sex with men (MSM), a high-risk group for human immunodeficiency virus (HIV) and other sexually transmitted infections (STI). Studies using population-based methods to estimate the number or percent of MSM or gay men were included. Twenty-eight studies met inclusion criteria. Seven studies used surveillance data, eighteen studies used survey data, and six studies used census data. Sixteen studies were conducted in the United States (US), five in European countries, two in Canada, three in Australia, one in Israel, and one in Kenya. Men who have sex with men accounted for 0.03% to 6.5% of men among all studies and ranged from 3.8% to 6.4% in the US, 7,000 to 39,100 in Canada, 0.03% to 6.5% in European countries, and 127,947 to 182,624 in Australia. Studies using surveillance data obtained the highest estimates of the MSM population size while those using survey data obtained the lowest estimates. Studies also estimated the MSM population size by dimensions of sexual orientation. In studies examining these dimensions, fewer people identified as MSM than reported experience with or

attraction to other men. Selection bias, differences in recall periods/sampling, or stigma could affect the estimate. It is important to have an estimate of the number of MSM to calculate disease rates, plan HIV/STI prevention efforts, and allocate resources for this group.

Keywords: men who have sex with men, estimation methods, population-based, MSM

Introduction

Male-to-male sexual contact accounted for 66.6% of new human immunodeficiency virus (HIV) diagnoses in 2017 and 72% of existing HIV infections at the end of 2016 in the United States (US) (CDC, 2018). Men who have sex with men (MSM) can be at high risk for HIV, but accurate estimates of this population are hard to obtain because census systems typically do not ask about sexual behavior or orientation, surveys are challenged with concerns about stigma, and measurement issues related to different domains of sexual orientation (e.g. behavior, identity, or attraction) (Wesson et al., 2017; Purcell et al., 2012).

Several methods have been developed to estimate the size of hard-to-reach populations (Wesson et al., 2017). Among these, population-based methods to estimate the size of the MSM population use the size of the general population combined with data on HIV prevalence among MSM from surveillance systems, the percentages of men reporting same-sex experience, attraction, or identity from large, national health surveys, or male-male unmarried partner household data from the US Census Bureau to produce estimates of MSM (Wesson et al., 2017; Grey et al., 2016).

It is difficult to estimate the size of this population directly due to stigma. Therefore, researchers have examined data about behavioral characteristics, attraction, or identity. Based on the specific calculation method, there may be men missing from the estimate if they have sex with men but do not consider themselves gay or bisexual. Many MSM identify as gay or bisexual, but not all (Grey et al., 2016). Other methods have been used to estimate population sizes and include capture-recapture, network scale-up, wisdom of the crowds, multiplier, and Delphi (Wesson et al., 2017; Abdul-Quader et al., 2014). These other methods have been covered in recent systematic reviews of estimating the size of hard-to-reach populations including MSM by Abdul-Quader et al. (2014) and Wesson et al. (2017) and are not included here to reduce duplication (Wesson et al., 2017; Abdul-Quader et al., 2014).

The objective of this systematic review was to summarize population-based methods to estimate the size of the male population that has sex with men, regardless of sexual identity and HIV status. Knowing the size of this population allows for calculating and monitoring HIV diagnosis rates over time and between regions (Purcell et al., 2012; Grey et al., 2016) and for tracking progress towards national objectives such as the US National HIV/AIDS Strategy goals of reducing the number of new HIV diagnoses by at least 25% by 2020 and expanding access to effective prevention services, including pre-exposure prophylaxis (PrEP) (Office of National AIDS Policy, 2015). Further, population size estimates can guide targeting of intervention programs and allocation of resources.

Methods

This systematic review was drafted in accordance with the Preferred Reporting Items for Systematic review and Meta-Analysis Protocols (PRISMA-P) guidelines and was registered with the International Prospective Register of Systematic Reviews (PROSPERO: CRD42018085368) (Shamseer et al., 2015; PROSPERO, n.d.). PubMed, Embase, and CINAHL were searched for relevant articles. Search terms (e.g., Mesh terms in PubMed) were related to population estimation and MSM/gay men. As an example, the following was used in PubMed: (population size estimat*) AND (("Homosexuality, Male"[Mesh]) OR ("Sexual and Gender Minorities"[Mesh]) OR ("men who have sex with men")). Search terms are shown in Table 1.

Inclusion criteria

The population of interest in this review was MSM, which could include but was not limited to men who identify as gay/bisexual and HIV-positive/negative men. Men who have sex with men is a behavioral definition that is often used by public health researchers and is preferred over identity or attraction because it is the behavior that can lead to sexual transmission of HIV/STIs (Grey et al., 2016). Studies using identity or attraction to estimate MSM were also included. A study was eligible for inclusion if it used population-based methods for estimating the MSM/gay population alone or in combination with other methods. That is, the studies used the size of the general population combined with data on HIV prevalence among MSM

from surveillance systems, percentages of men reporting same-sex experience, attraction, or identity from large, national health surveys, and male-male unmarried partner household data from census data to produce estimates of MSM (Wesson et al., 2017; Grey et al., 2016). Only peer-reviewed literature was included. Conference abstracts, commentaries, and other papers that did not report on original research were excluded. No time limits or location restrictions were applied.

Screening and data extraction

Three databases were searched through November 9, 2018. Duplicates were removed using RefWorks and Covidence (RefWorks, n.d.; Covidence, n.d.). Covidence was used to manage screening of studies (Covidence). Two reviewers (D.E.M. and M.T.G.) independently screened articles by a) title and abstract, and b) full-text. The reference lists of articles selected for inclusion were searched for additional studies. Any conflicts were resolved by discussion and consensus at each screening step.

Data were extracted independently by D.E.M. and M.T.G. after full-text screening was completed. Variables extracted from the studies included author and year of publication, location where the study was conducted, calculation method used for estimating the MSM population, sources of data for calculation, percentage of MSM reported, and number of MSM reported. Any conflicts were resolved by discussion and consensus.

Results

The flowchart in Figure 1 shows the number of studies at each step of the screening process. During title/abstract screening, 183 studies were excluded because they were not relevant. Twenty-eight studies met the inclusion criteria and were included in data extraction. Sixteen studies were conducted in the United States. The other 12 studies were conducted in Canada (n=2), Australia (n=3), Germany (n=1), Israel (n=1), Kenya (n=1), the United Kingdom (n=2), Norway (n=1), and multiple countries in Europe (n=1). All studies were published in English. The studies fell into three general categories: surveillance-based methods (n=7), survey-based methods (n=18), and census-based methods (n=6). Two studies used multiple methods. The studies are listed in Tables 2–4.

Description of specific calculation methods and data sources

Surveillance-based methods used prevalence or testing data from HIV surveillance systems (Grey et al., 2016). The following formula was used in Raymond et al. (2018) and can be used as a guide: (HIV cases in the registry ∗ % undiagnosed HIV infection) / % HIV prevalence (Raymond et al., 2018). Numerators in studies included the number of MSM tested for HIV in Canada from provincial serodiagnostic databases (Archibald et al., 2001), HIV prevalence among MSM in Miami from the Florida Department of Health (Lieb et al., 2004; Lieb et al., 2007), the average HIV seroprevalence rate for young Black MSM (YBMSM) from the Chicago Department of Public Health (Livak et al., 2013), the number of survey

participants diagnosed with HIV in 2009 in 38 European countries, the proportion of MSM, and the number of men in a country (Marcus et al., 2013), and HIV/AIDS cases and an estimate of undiagnosed HIV infection from case surveillance data in San Francisco (Raymond et al., 2013; Raymond et al., 2018). Denominators included the proportion of MSM that reported HIV testing in Canada from studies (Archibald et al., 2001), estimated HIV seroprevalence among MSM from the US Urban Men's Health Study (Lieb et al., 2004), HIV seropositivity rates among MSM from the US National HIV Behavioral Surveillance system (NHBS) (Lieb et al., 2007), population-based seroprevalence rate among YBMSM in Chicago from NHBS and Social Risk and Network Assessment (Livak et al., 2013), the sample size from a national survey and the number of HIV cases diagnosed among MSM in 2009 (Marcus et al., 2013), and HIV prevalence from studies and case counts (Raymond et al., 2013), and NHBS (Raymond et al., 2018) (Table 2).

Survey-based methods used a percentage or proportion of men reporting same-sex experience (behavior), attraction, or identity from national probability surveys and the male population from a census (Grey et al., 2016). Many surveys rely on questions related to sex with a man during the previous 12 months, five years, or ever (Grey et al., 2016). An example of a formula used in Livak et al. (2013) is listed here: percent of Black MSM from National Survey of Family Growth * the number of young Black males from 2010 US Census (Livak et al., 2013). Surveys measured the following behaviors: proportion of men reporting MSM behavior in the past year from the Canada Health Monitor (Archibald et al., 2001), the percent of the

adult male population that had ever had sex with a man from National Health and Nutrition Examination Survey (NHANES) (Harris et al., 2013), proportions of MSM from NHBS (Hughes et al., 2017), percent of men who reported ever having sex with another man from National Survey of Family Growth (NSFG) (Livak et al., 2013), percentage of same-sex attraction, experience, or identity from Australian Study of Health and Relationships (ASHR) (Madeddu et al., 2006), any same sex attraction, lifetime history of same-sex sexual behavior, or self-identification as gay or bisexual (Mor et al., 2016), prevalence of MSM occurrence (Okal et al., 2013), recent male-male sex from NHANES (Oster et al., 2016), current homosexual or bisexual identity from ASHR (Prestage et al., 2008), same-sex behavior in the past 5 years (Purcell et al., 2012), proportion of homosexual experience from postal surveys (Veierod et al., 1997), same sex attraction, experience, or identity from National Survey of Sexual Attitudes and Lifestyles III (NATSAL III) (Geary et al., 2018), proportion of men who identified as gay from ASHR 2 (Zablotska et al., 2018), and the proportion who had at least one male sex partner in the previous year from ASHR 2 (Zablotska et al., 2018) (Table 3).

Census-based methods used national census data such as the proportion of men age 45 and older that had never been married or the percent of male-male unmarried partner households (Grey et al., 2016; Archibald et al., 2001). The formula from de Voux et al. (2017) is provided here as an example: percent of male same-sex households in a county from the American Community Survey (ACS) * the number of men in the county from ACS (de Voux et al., 2017). Numerators included the

proportion of men age 45 and older that had never been married from a census (Archibald et al., 2001), percent of male-male unmarried partner households in a county from census data (de Voux et al., 2017; Grey et al., 2016), and same sex male partners in a state from census data (Lieb et al., 2009; Lieb et al., 2011; Campagna et al., 2015) and county (Campagna et al., 2015). Denominators included the census population of adult men age 15 and over from a census (Archibald et al., 2001) and the number of men in a county or state from ACS or census data (Grey et al., 2016; de Voux et al., 2017; Campagna et al., 2015) (Table 4).

Sampling/recruitment

Samples in surveillance-based studies included all individuals who came for HIV testing (Archibald et al., 2001), persons diagnosed with HIV and reported to Florida Department of Health (Lieb et al., 2004; Lieb et al., 2007), YBMSM living with HIV in Chicago (Livak et al., 2013), national surveillance data on newly diagnosed HIV infections among MSM (Marcus et al., 2013), and HIV case registry for San Francisco (Raymond et al., 2013; Raymond et al., 2018). Samples in survey-based studies included the population reporting MSM behavior in the past year or lifetime (Archibald et al., 2001), the civilian general household population (Harris et al., 2013; Oster et al., 2016; Esie et al., 2018), MSM in San Francisco through standardized behavioral surveys (Hughes et al., 2017), a nationally representative multi-stage area probability sample survey from US households (Livak et al., 2013), a national representative population-based survey (Madeddu et al., 2006; Prestage et al., 2008; Zablotska et al., 2018), behavioral surveys among MSM (Marcus et al.,

2009), a random sample of Jewish males (Mor et al., 2016), probability and stratified cluster samples of US households (Purcell et al., 2012), a national population-based cross-sectional survey (Rich et al., 2018), a probability sample survey (Ruf et al., 2011; Geary et al., 2018), a stratified random sample of youth (Shield et al., 2013), and simple random samples in Norway (Veierod et al., 1997). Census-based studies used data from the US Census Bureau (Grey et al., 2016; de Voux et al., 2017; Lieb et al., 2009; Lieb et al., 2011; Campagna et al., 2015) or a national census (Archibald et al., 2001).

Estimates of the MSM population by location

Men who have sex with men accounted for 0.03% to 6.4% of men among all studies and ranged from 3.8% to 6.4% in North America, 0.03% to 6.5% in European countries, and 127,947 to 182,624 in Australia. Several studies estimated MSM for the US as a whole using various methods (Harris et al., 2013; Oster et al., 2016; Purcell et al., 2012; Esie et al., 2018; de Voux et al., 2017; Lieb et al., 2011; Grey et al., 2016). Harris et al. (2013) estimated that 4.7% of men were MSM and or about 4.5 million MSM (Harris et al., 2013). Oster et al. (2016) estimated that 4.7% of men had ever had male-male sex and 2.2% of men had male-male sex in the past 12 months (Oster et al., 2016). Purcell et al. (2012) estimated that 3.9% of men engaged in same-sex behavior in the past five years (Purcell et al., 2012). Esie et al. (2018) estimated that the prevalence of having at least one lifetime same-sex partner was 5.5% (Esie et al., 2018). In de Voux et al. (2015), it was reported that 3.8 % of men or about 3.9 million men were MSM (de Voux et al., 2017). Lieb et al. (2011)

estimated that the overall percentage of males in the US who were MSM was 6.4% or 7.1 million (Lieb et al., 2011). In Grey et al. (2016), the authors reported that 3.9% of men or 4.5 million men in the US were MSM (Grey et al., 2016). Studies in the US as a whole have estimated that 3.8% to 6.4% of men are MSM for a population of 3.9 to 7.1 million men.

Studies have also estimated MSM within US states or cities (Lieb et al., 2009; Campagna et al., 2015; Raymond et al., 2013; Raymond et al., 2018; Hughes et al., 2017; Shields et al., 2013; Lieb et al., 2004; Lieb et al., 2007). Lieb et al. (2009) reported that 6% of men or 2.4 million men in the South were MSM (Lieb et al., 2009). Campagna et al. (2015) estimated at 6.4% of men in Texas were MSM (Campagna et al., 2015). Four studies estimated the number of MSM in San Francisco, California. Raymond et al. (2013) estimated the number of MSM using HIV surveillance data and reported 59,809 MSM (Raymond et al., 2013). Raymond et al. (2018) used HIV case registry data and NHBS survey data to estimate that 63,242 men in San Francisco were MSM (Raymond et al., 2018). Hughes et al. (2017) used data from the NHBS and reported that there were 58,605 MSM in 2014 (Hughes et al., 2017). Shields et al.(2013) used data from the 2011 YRBS and found that 3.8% of middle school students identified as lesbian, gay, or bisexual (LGB) (Shields et al., 2013). Studies in San Francisco estimated 58,605–63,242 MSM, with 3.8% of middle school students identifying as LBG.

Two studies estimated that the percentage of MSM in Miami, Florida ranged from 7.5 to 9.5% of men or 63,020–76,500 men (Lieb et al., 2004; Lieb et al., 2007).

Lieb et al. (2004) used data from the Florida Department of Health and reported that 9.5% of men or 76,500 men were MSM (Lieb et al., 2004). Lieb et al. (2007) used data from the Florida Department of Health and the NHBS and reported that 7.5% of men or 63,020 men were MSM (Lieb et al., 2007).

Two studies estimated the number of MSM in Canada using various methods. The estimated number of MSM in Toronto varied from 18,800 using data from surveys to 39,100 using surveillance-based data (Archibald et al., 2001). The number in Vancouver varied from 7,000 using survey data to 26,500 using census-based data (Archibald et al., 2001). In Montreal, the number of MSM varied from 18,500 using survey data to 37,000 using census-based data (Archibald et al., 2001). Rich et al. (2018) used data from surveys conducted in 2011–2012 and 2013–2014, and estimated 3.3% of adult men or 30,605 MSM in Metro Vancouver (Rich et al., 2018).

Three studies estimated the size of the MSM population in Australia (Madeddu et al., 2006; Prestage et al., 2008; Zablotska et al., 2018). Madeddu et al. (2006) reported that the inner east postcode areas in Sydney ranged from 12.9% to 52.8% for same-sex attraction, 9.8% to 51.5% for same-sex behavior, and 4.4% to 48.1% for same-sex identity (Madeddu et al., 2006). The percent for the inner west postcode areas in Sydney ranged from 25.1% to 55.9% for same-sex attraction, 25.1% to 35.6% for same-sex behavior, and 13.5% to 34.3% for same-sex identity (Madeddu et al., 2006). Prestage et al. (2008) estimated that 2.5% of men overall identified as homosexual or bisexual, with 3.0% in New South Wales, 2.3% in Victoria, and 2.7%

in Queensland (Prestage et al., 2008). Zablotska et al. (2018) estimated that there were 127,947 sexually active 16–69 year-old gay men (Zablotska et al., 2018).

Five studies were conducted in Europe (Marcus et al., 2013; Marcus et al., 2009; Ruf et al., 2011; Veierod et al., 1997; Geary et al., 2018). Marcus et al. (2013) estimated that relative MSM population sizes were between 0.03% and 5.6% of the adult male population aged 15–64 in 38 countries (Marcus et al., 2013). Marcus et al. (2009) estimated that 2.9% of men in Germany were MSM (Marcus et al., 2009). Ruf et al. (2011) reported that 5.5% of men or 98,330 MSM were living in inner London in 2008 (Ruf et al., 2011). Veierod et al. (1997) reported that 3.8% of men in Norway reported homosexual practice during their lifetime and 1.2% during the past three years (Veierod et al., 1997). Geary et al. (2018) found that 1.5% of 16–74 year-old men self-identified as gay, 6.5% of men reported any same-sex sexual attraction, and 5.5% of men reported same-sex sex ever in Britain (Geary et al., 2018). Studies in 38 countries Europe have estimated that 0.03–6.5% of men are MSM.

Estimates of MSM by dimensions of sexual orientation

A few studies reported estimates for all three dimensions of sexual orientation. In these, estimates were generally smaller for identity than experience or attraction. Madeddu et al. (2006) reported that the percent for the inner east postcode areas in Sydney ranged from 12.9% to 52.8% for same-sex attraction, 9.8% to 51.5% for same-sex behavior, and 4.4% to 48.1% for same-sex identity (Madeddu et al., 2006). The inner west postcode areas in Sydney ranged from 25.1% to 55.9% for same-sex

attraction, 25.1% to 35.6% for same-sex behavior, and 13.5% to 34.3% for same-sex identity (Madeddu et al., 2006). Prestage et al. (2008) estimated that 2.5% of men overall in Australia identified as homosexual or bisexual (Prestage et al., 2008). Zablotska et al. (2018) estimated that there were 127,947 of sexually active 16–69 year-old gay men in Australia (Zablotska et al., 2018). Shields et al. (2013) reported that 3.8% of middle school students identified as lesbian, gay, or bisexual in San Francisco (Shields et al., 2013). Mor et al. (2016) reported that 11.9% of men reported lifetime male sexual encounters while 4.5% identified as gay in Israel (Mor et al., 2016). Geary et al. (2018) found that 1.5% of 16–74 year-old men self-identified as gay, 6.5% of men reported any same-sex sexual attraction, and 5.5% of men reported same-sex sex ever in Britain (Geary et al., 2018).

Discussion

Researchers are currently using three general types of population-based methods to estimate the number of MSM. Surveillance-based methods use HIV data from surveillance systems such as the number of HIV tests performed, HIV prevalence, or HIV seropositivity to estimate the size of the MSM population. Survey-based methods use a percentage or proportion of MSM from a national survey and the male population from the census to estimate the number of MSM. Census-based methods use data from the US Census Bureau, such as the number or percent of male-male unmarried partner households, to estimate the number of MSM. Studies in the US have estimated that 3.8–6.4% of men are MSM for a population of 3.9–7.1 million men (de Voux et al., 2017; Lieb et al., 2011). Studies in 38 countries in

Europe estimated that 0.03–6.5% of men are MSM (Marcus et al., 2013). Studies in Canada estimated that MSM accounted for 7,000–30,605 men in Vancouver, 18,000–39,100 men in Toronto, and 18,500–37,000 men in Montreal (Archibald et al., 2001; Rich et al., 2018). Studies in Australia found that 127,947–182,624 men identified as homosexual or bisexual (Zablotska et al., 2018; Prestage et al., 2008). A study in Britain estimated that 1.5% of 16–74 year-old men self-identified as gay, 6.5% reported any same-sex sexual attraction, and 5.5% reported same-sex sex ever (Geary et al., 2018). The study populations were characterized using same-sex sexual contact or attraction, identification as homosexual or bisexual, never having been married, or households with a male head and a male partner. The results were similar overall between the different population characterizations.

Stigma can impact the range of estimates of MSM population size between countries. People may be hesitant to admit to stigmatized behaviors or identities in surveys (Purcell et al., 2012; Abdul-Quader et al., 2014). The proportion of men that openly identify as MSM depends on social acceptance, and differs between countries and regions (Marcus et al., 2009; Lieb et al., 2011). Societal marginalization, stigmatization, and denial of the existence of MSM in countries can lead to lack of appropriate prevention programs and an underestimation of needs and treatment (Okal et al., 2013). This could explain why the Kenya study estimate by Okal et al. (2013) and the Turkey estimate in Marcus et al. (2013) (0.03%) were lower than other studies. Stigma could also lead to males inaccurately reporting their relationship to the head of household in census-based studies (Campagna et al., 2015).

Underreporting of same-sex behavior or identity due to stigma could result in an underestimate of the size of the MSM population (Purcell et al., 2012).

Wesson et al. (2017) and Abdul-Quader et al. (2014) recently conducted systematic reviews on methods of population size estimation of hard-to-reach populations such as MSM, people who inject drugs, and female sex workers (Wesson et al., 2017; Abdul-Quader et al., 2014). However, these studies did not report population estimates. Additionally, there was little overlap in studies included in those reviews and the present review.

Strengths of population-based methods

Each of the methods has particular strengths. Surveillance-based methods can be used to estimate the number of MSM that are at high risk for HIV infection (Raymond et al., 2013). People being tested for HIV may be engaging in higher risk activities (Raymond et al., 2013). Survey-based methods may use a national sample and can estimate MSM in the general population (Purcell et al., 2012). Survey-based methods can be used to estimate the size of the MSM population based by different dimensions of sexual orientation such as attraction, behavior, or identity (Madeddu et al., 2006; Geary et al., 2018). Behavior would be the most important dimension as it can lead to sexual transmission of HIV and STIs (Grey et al., 2016). The census-based method first used in Lieb et al., 2009 could easily be used to estimate the number or percent of MSM as it uses publicly available data and is inexpensive in terms of time and money (Lieb et al., 2009). It can be used to estimate MSM by the

various geographic units that are available in census data (e.g., state, county) (Lieb et al., 2009; Esie et al., 2018; Grey et al., 2016). These methods could also be used in an overlapping manner or together, but it depends on study design, data collection, measures, and the analysis used. Using multiple methods could provide a more robust estimate than a single method (Raymond et al., 2018).

Limitations of population-based methods

Each of the methods has limitations that could result in inaccurate estimates of the MSM population. The surveillance-based method does not always include people who are HIV positive but unaware of their diagnosis. These studies used people at risk for or infected with HIV and may overestimate the population size as those being tested for HIV may be more likely to engage in high-risk activity (selection bias) (Raymond et al., 2013). People attending an STD clinic may be engaging in high-risk activities and could lead to an overestimate (Raymond et al., 2013). Survey-based methods may have small sample sizes, which is a problem if the behavior is rare (Archibald et al., 2001). This can result in a broad range for the estimates (Archibald et al., 2001). The questions used to identify MSM or recall periods may not be the same across surveys (Archibald et al., 2001; Purcell et al., 2012). People may be reluctant to self-report sensitive behaviors due to stigma (Archibald et al., 2001; Livak et al., 2013; Purcell et al., 2012). The focus of the survey could also affect the estimate (e.g., people at risk for HIV may not represent all MSM) (Harris et al., 2013). The delivery method of the survey may also affect the estimate (interviewer or self-administered) (Rich et al., 2018). Survey-based methods often use national

surveys and may not allow for generalization to or be representative of small geographic units (Purcell et al., 2012). Additionally, the MSM population may vary by location (Grey et al., 2016). The census-based method also has limitations. Error in classification of male-male unmarried partner households has been reported, which could affect the accuracy of these estimates (O'Connell & Feliz, 2011). Stigma could lead to males inaccurately reporting their relationship and an underestimate of the data used in these studies (Campagna et al., 2015). National estimates were used to derive state estimates used in the calculations, and this could be inadequate due to uneven dispersion of MSM (Grey et al., 2016; Lieb et al., 2009).

Limitations of this review

This review was limited to articles published in peer-reviewed journals and excluded work presented in conference abstracts. Additionally, articles published in journals not indexed in the databases used would not be included in the review.

Conclusions

Estimating populations at risk for HIV infection is a priority for international organizations, such as the World Health Organization (Wesson et al., 2017). Knowing the size of MSM population is important to interpret HIV and STI surveillance data, and to appropriately allocate resources and target prevention programs such as PrEP. Because MSM behavior is not ascertained in censuses, it is not easy to determine the number of MSM. Asking people about their sexual behavior is sensitive, and estimates may not be accurate due to stigma or privacy

concerns. Additionally, census questions often ask about identification, not behavior. Currently, there is no agreed upon method to estimate the size of the MSM population. Research can use available sources of data such as surveillance data, surveys, or census data. The choice of method for estimating the size of the MSM population can affect the results. In this review, studies using surveillance data obtained the highest estimates while those using survey data obtained the lowest estimates. Future studies could estimate the number of HIV-negative MSM, by rural/urban residence, by PrEP eligibility, by gay-friendly neighborhoods, or by small geographic units such as census tracts or ZIP codes. In the meantime, researchers wishing to estimate the MSM population should consider using multiple methods to balance out the limitations of each method alone. Doing so could lead to a more robust estimate.

References

Abdul-Quader AS, Baughman AL, Hladik W. Estimating the size of key populations: current status and future possibilities. *Current Opin HIV AIDS*. 2014;9(2):107–114.

Archibald CP, Jayaraman GC, Major C, Patrick DM, Houston SM, Sutherland D. Estimating the size of hard-to-reach populations: a novel method using HIV testing data compared to other methods. *AIDS*. 2001;15(Suppl 3):s41–48.

Campagna J, Poe J, Robbins A, Rowlinson E. Estimating the number of men who have sex with men by race/ethnicity at the county level in Texas. *J Urban Health*. 2015;92(1):168–181.

Centers for Disease Control and Prevention. HIV Surveillance Report, 2017; vol. 29. 2018. Available at: https://www.cdc.gov/hiv/pdf/library/reports/surveillance/cdc-hiv-surveillance-report-2017-vol-29.pdf

Covidence. Cochrane Collaboration. No date. Available at: https://www.covidence.org/home.

de Voux A, Kidd S, Grey JA, et al. State-specific rates of primary and secondary syphilis among men who have sex with men-United States, 2015. *MMWR Morb Mortal Wkly Rep*. 2017;66(13):349–354.

Esie P, Kang J, Flagg EW, Hong J, Chen T, Bernstein K. Men who have sex with men-Identification criteria and characteristics from the National Health and Nutrition Examination Survey, 1999 to 2014. *Sex Transm Dis*. 2018;45(5):337-342.

Geary RS, Tanton C, Erens B, et al. Sexual identity, attraction and behaviour in Britain: The implications of using different dimensions of sexual orientation to estimate the size of sexual minority populations and inform public health interventions. *PLOS One*. 2018;13(1): e0189607.

Grey JA, Bernstein KT, Sullivan PS, et al. Estimating the population sizes of men who have sex with men in US states and counties using data from the American Community Survey. *JMIR Public Health Surveill*. 2016;2(1):e14.

Harris N, Johnson C, Sionean C, et al. Estimated percentages and characteristics of men who have sex with men and use injection drugs-United States, 1999-2011. *MMWR Morb Mortal Wkly Rep*. 2013;62(37):757–762.

Hughes AJ, Chun Y, Scheer S, Raymond HF. A novel modeling approach for estimating patterns of migration into and out of San Francisco by HIV status and race among men who have sex with men. *J Urban Health*. 2017;94(3):350–363.

Lieb S, Friedman SR, Zeni MB, et al. An HIV prevalence-based model for estimating urban risk populations of injection drug users and men who have sex with men. *J Urban Health*. 2004;81(3):401–415.

Lieb S, Trepka MJ, Thompson DR, et al. Men who have sex with men: estimated population sizes and mortality rates by race/ethnicity, Miami-Dade County, Florida. *J Acquir Immune Defic Syndr*. 2007;46(4):485–490.

Lieb S, Thompson DR, Misra S, et al. Estimating populations of men who have sex with men in the Southern United States. *J Urban Health*. 2009;86(6):887–901.

Lieb S, Fallon SJ, Friedman SR, et al. Statewide estimation of racial/ethnic populations of men who have sex with men in the US. *Public Health Rep*. 2011;126(1):60–72.

Livak B, Michaels S, Green K, et al. Estimating the number of young Black men who have sex with men (YBMSM) on the South side of Chicago: towards HIV elimination within US urban communities. *J Urban Health*. 2013;90(6):1205–1213.

Madeddu D, Grulich A, Richters J, et al.. Estimating population distribution and HIV prevalence among homosexual and bisexual men. *Sex Health*. 2006;3(1):37–43.

Marcus U, Schmidt AJ, Hamouda O, Bochow M. Estimating the regional distribution of men who have sex with men (MSM) based on internet surveys. *BMC Public Health*. 2009;9:180.

Marcus U, Hickson F, Weatherburn P, Schmidt AJ, the EMIS Network. Estimating the size of the MSM populations for 38 European countries by calculating the survey-surveillance discrepancies (SSD) between self-reported new HIV diagnoses from the European MSM internet survey (EMIS) and surveillance reported HIV diagnoses among MSM in 2009. *BMC Public Health*. 2013;13:919.

Mor Z, Davidovich U. Same-sex sexual attraction, behavior, and practices of Jewish men in Israel and the association with HIV prevalence. *AIDS Care*. 2016;28(Suppl 1):64–67.

Office of National AIDS Policy. National HIV/AIDS Strategy Updated to 2020. 1–65; 2015. Available at: https://files.hiv.gov/s3fs-public/nhas-update.pdf.

O'Connell M, Feliz S. Same-sex couple household statistics from the 2010 Census. Bureau of the Census. 2011. Available at: https://www.census.gov/library/working-papers/2011/demo/SEHSD-WP2011-26.html.

Okal J, Geibel S, Muraguri N, et al. Estimates of the size of key populations at risk for HIV infection: men who have sex with men, female sex workers and injecting drug users in Nairobi, Kenya. *Sex Transm Infect*. 2013;89(5):366–371.

Oster AM, Sternberg M, Lansky A, Broz D, Wejnert C, Paz-Bailey G. Population size estimates for men who have sex with men and persons who inject drugs. *J Urban Health*. 2016;92(4):733–43.

Prestage G, Ferris J, Grierson J, et al. Homosexual men in Australia: population, distribution and HIV prevalence. *Sex Health*. 2008;5(2):97–102.

PROSPERO. International prospective register of systematic reviews. University of York. No date. Available at: https://www.crd.york.ac.uk/.

Purcell DW, Johnson CH, Lansky A, et al. Estimating the population size of men who have sex with men in the United States to obtain HIV and syphilis rates. *Open AIDS J*. 2012;6:98–107.

Raymond HF, Bereknyei S, Berglas N, Hunter J, Ojeda N, McFarland W. Estimating population size, HIV prevalence and HIV incidence among men who have sex with men: a case example of synthesizing multiple empirical data sources and methods in San Francisco. *Sex Transm Infect*. 2013;89(5):383–387.

Raymond HF, McFarland W, Wesson, P. Estimated population size of men who have sex with men, San Francisco, 2017. *AIDS Behav*. 2018; Epub ahead of print.

RefWorks. ProQuest LLC. No date. Available at: https://www.refworks.com/refworks2/default.aspx.

Rich AJ, Lachowsky NJ, Sereda P, et al. Estimating the size of the MSM population in metro Vancouver, Canada, using multiple methods and diverse data sources. *J Urban Health*. 2018;95(2):188–195.

Ruf M, Delpech V, Osuagwu U, Brown AE, Robinson E, Chadborn T. Men who have sex with men: estimating the size of at-risk populations in London primary care trusts. *Int J STD AIDS*. 2011;22(1):25–29.

Shamseer L, Moher D, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. *BMJ*. 2015;349:g7647.

Shields JP, Cohen R, Glassman JR, Whitaker K, Franks H, Bertolini I. Estimating population size and demographic characteristics of lesbian, gay, bisexual, and transgender youth in middle school. *J Adolesc Health*. 2013;52(2):248–250.

Veierod MB, Eskild A, Stigum H, Johannes T, Per M. Prevalence and trends in homosexual behaviour in Norway. *Scand J Soc Med*. 1997;25(1):33–38.

Wesson P, Reingold A, McFarland W. Theoretical and empirical comparisons of methods to estimate the size of hard-to-reach populations: a systematic review. *AIDS Behav*. 2017;21(7):2188–2206.

Zablotska IB, Gray R, Whittaker B, et al. The estimated number of potential PrEP users among gay-identifying men who have sex with men in Australia. *PLOS One*. 2018;13(10):e0204138.

Tables and figures

Table 1. Search terms for databases

Keywords	PubMed subject terms	Embase subject terms	CINAHL subject terms
Population size estimation/estimates	population size estimat*	'population size'/de	(MH "Population Characteristics+")
men who have sex with men, gay men	"Sexual and Gender Minorities"[Mesh] OR "homosexuality, male" [Mesh] OR "men who have sex with men"	'men who have sex with men'/de OR 'LGBT people'/exp	(MH "Men Who Have Sex With Men") OR (MH "Gay Men")

Table 2. Studies using surveillance-based methods for estimating the number of men who have sex with men

Author, year	Country/State/City	Calculation	Source of data, years	Percent of MSM	Number of MSM	Sampling method	Characterization of study population
Archibald et al., 2001	Canada/Toronto, Montreal, Vancouver	Number of MSM[a] tested for HIV[b] in 1996 from provincial serodiagnostic databases/proportion of MSM that reported being tested for HIV during a 1 year period from surveys and studies	Provincial serodiagnostic databases and epidemiologic studies	Not reported	Toronto= 39,100, Vancouver =15,900	All individuals who come forward for HIV testing	Sex with other men, self-identification as gay, or sexual relations with other men
Lieb et al., 2004	United States/Florida/Miami MSA[c]	HIV prevalence among MSM in Miami (extrapolated from national estimate)/estimated HIV seroprevalence rates among MSM from Urban Men's Health Study	Florida Department of Health	9.5%	76,500	Persons diagnosed and reported to the Florida Department of Health HIV/AIDS Reporting System	Male resident aged 18 years or older who had any male–male sex contact after 1977
Lieb et al., 2007	United States/Florida/Miami-	HIV prevalence in Miami MSA/HIV seropositivity rates from NHBS[d]	Florida Department of Health, NHBS	7.5%	63,020 in Miami MSA for	HIV-infected MSM living and residing	All men aged ≥18 years who had male-

	Dade County MSA				2003 to 2005	in the Miami MSA	male sex contact since 1978
Livak et al., 2013	United States/Illinois/Chicago	Average HIV Seroprevalence Rate for YBMSM[e] (adjusted for HIV positive but unaware)/Population-Based Seroprevalence Rate among YBMSM (averaged from NHBS and SRN[f]);	Chicago Department of Public Health, 2010 US Census, NHBS, and SRN.	11.7%	6,340	YBMSM living with HIV infection in Chicago	Men who have had male–male sexual contact
Marcus et al., 2013	Europe	Npop = HIVpop*Nsvy*SSD/HIVsvy HIVpop, the number of HIV cases diagnosed among MSM reported to the countries surveillance system in 2009; Nsvy, the sample size in a national survey; HIVsvy, the number of those survey participants diagnosed with HIV in 2009; Ntot, the number of men in the country; M, the proportion who have sex with men SSD=HIVsvy*M*Ntot/Nsvy*HIVpop	EMIS[g], National surveillance data from ECDC[h], Eurostat, and from national statistics	Relative MSM population sizes were between 0.03% and 5.6% of the adult male population aged 15–64	Not reported	National surveillance data on newly diagnosed HIV infections among MSM	Having had at least one sexual contact with a man within the previous 12–24 months

Raymond et al., 2013	United States/California/San Francisco	(HIV/AIDS[i] Cases * undiagnosed infection)/HIV prevalence	Case surveillance data, HIV prevalence estimates, US Census data, and undiagnosed HIV infection estimate	Not reported	59,809 MSM	Total number of known MSM and MSM-IDU[j] HIV/AIDS cases in registry	Not listed
Raymond et al., 2018	United States/California/San Francisco	HIV cases in registry ∗ % undiagnosed HIV infection)／% HIV prevalence	HIV prevalence from NHBS survey in 2017 and proportion of MSM previously diagnosed with HIV from case registry in 2016	Not reported	63,242 MSM	HIV case registry for the city of San Francisco	Not listed

Abbreviations:

[a]MSM-Men who have sex with men

[b]HIV-Human immunodeficiency virus

[c]MSA-Metropolitan statistical area

[d]NHBS-National HIV Behavioral Surveillance

[e]YBMSM-Young black men who have sex with men

[f]SRN-Social Risk and Network Assessment

[g]EMIS-European MSM Internet Survey

[h]ECDC-European Centre for Disease Prevention and Control

[i]AIDS-Acquired Immune Deficiency Syndrome

[j]IDU-Injection drug user

Table 3. Studies using survey-based methods for estimating the number of men who have sex with men

Author, year	Country/State/ City	Calculation	Source of data, years	Percent of MSM	Number of MSM	Sampling method	Characterization of study population
Archibald et al., 2001	Canada/Toronto, Montreal, Vancouver	Proportion of population reporting MSM[a] behavior in past year * male population over 15	1994 and 1997 CHM[b] survey	Not reported	Toronto= 18,800, Montreal= 18,500, Vancouver= 7,000	Population reporting MSM behavior in the past year/lifetime	Having had oral or anal intercourse with another man in the past year/lifetime
Purcell et al., 2012	United States	Applied the proportion of men reporting same-sex behavior in the past 5 years from literature search to United States census data	4 surveys, United States census data	3.9% of men engaged in same-sex behavior in past 5 years	4,791,262 MSM 13 and older in 2008	Probability samples, stratified cluster sample of US households	Men who reported same-sex behaviors or partners
Livak et al., 2013	United States/Illinois/ Chicago	4.2% * young Black males in the South side of Chicago	NSFG[c] 2006-2010, 2010 US Census	4.2%	2,286	nationally representative multi-stage area probability sample survey	Men who have had male–male sexual contact

						from US households	
Harris et al., 2013	United States	Percent from NHANES[d] * adult male population	NHANES 1999–2008	4.7%	3,555,568	civilian general household population	Men who ever had sex with a man
Hughes et al., 2017	United States/California/San Francisco	Means of the proportions of MSM by race were calculated from NHBS[e] 2004 and 2008/total adult male pop in San Francisco in 2006	NHBS; United States census	19.0% of adult males were MSM; 23.0% of all black adult males and 21.0% of all white males	58,605 in 2014, 14,452 were HIV[f] positive and 44,154 were HIV negative; 32,705 were white and 4,419 were black MSM in 2014	Data on MSM in San Francisco through standardized behavioral surveys	Not listed
Madeddu et al., 2006	Australia/Sydney	Applied percentage of same-sex attraction, experience, or identity from ASHR[g] for each postal code to the number of male residents of a similar age in those same postcode areas	2000/2001 Sydney Gay Community Periodic Survey, ASHR 2003, and Australian Household Census 2001	The proportion of men who identified as homosexual or bisexual ranged from 4.4%	Selected inner east: identity-9,269, experience-12,979, attraction-13,508. Selected inner west: identity-3,464, experience-	national representative population-based survey, participants were selected at random from the	Male participants who reported lifetime experience of sex with men, feelings of same-sex attraction

				to 48.1%; 9.8% to 51.5% of men reported same-sex experiences during their lifetime; and 12.9% to 52.8% of men had ever experienced feelings of same-sex attraction	4,797, attraction-5,573	general population to participate in a telephone survey	during their lifetime, and/or a current homosexual or bisexual identity
Marcus et al., 2009	Germany	Based on the proportional regional distribution of survey participants and user profiles, assuming a total population size of 600,000	KABaSTI[h]-study 2006 and GMA[i]-2007-survey	2.6%	Not reported	Both were behavioural surveys among MSM, participants were recruited online (and	Male participants in the age group 20–50 years who reported sexual contacts with men

						offline too for GMA)	in the previous 12 months
Mor et al., 2016	Israel	Projected the rates of study participants who reported sexual behavior, which included MSM, by the relevant Israeli population using the 2012 Statistical Abstract of Israel	Anonymous electronic questionnaire, Statistical Abstract of Israel	11.9% reported lifetime male sex encounters, 4.5% self-identified as gay and 3.7% as bisexual	94,176 in Israel and 33,839 in Tel-Aviv gay/bisexual	Random sample from representative sample of Jewish males aged 18–44 years who completed an anonymous electronic questionnaire	Same-sex sexual attraction; oral or anal intercourse with another man; self-identification
Okal et al., 2013	Kenya/Nairobi	Men 18 plus * estimate of prevalence in population from Caceres 2008	Caceres et al., 2008 and 2009 Nairobi census	1.2%	13,608 MSM		Had oral or anal sex with man
Oster et al., 2015	United States	Weighted prevalence estimate from NHANES by the population estimate	1999–2010 NHANES, Vintage 2011 file from the United States Census Bureau	4.7% of men had ever had male-male sex and 2.2% of men had	5,933,000 ever; 3,156,000 in past 12 months	Nationally representative sample of the civilian, noninstituti	Among men, having had oral or anal sex with another man during

				male-male sex in the past 12 months		onalized population	the past 12 months/ever
Prestage et al., 2008	Australia	Percentage of male participants in ASHR who reported a current homosexual or bisexual identity were applied to the number of adult male residents in the respective states from 2001 Australian Household Census	ASHR, 2001 Australian Household Census	2.5% overall; 3.0% in New South Wales; 2.3% in Victoria; 2.7% in Queensland	182,624 total; 74,420 in New South Wales; 41,990 in Victoria; 36,935 in Queensland	National representative population based survey, computer-assisted telephone interviews	Male participants in ASHR who reported a current homosexual or bisexual identity
Rich et al., 2018	Canada/Vancouver	Calculated median estimate for Vancouver urban core from 2 survey cycles	CCHS[j] 2011–2012 and 2013–2014 (median)	3.3% (median)	30,605	National population-based cross-sectional survey, interviewer administered telephone surveys	Number of self-identified homosexual, gay, or bisexual men aged 18–59 years
Ruf et al., 2011	United Kingdom/London	Estimated inner London MSM proportion from	British NATSAL 2000 and	5.5%	98,330 MSM aged 16-44 were living in	Probability sample survey of	Partners of the same gender

		NATSAL[k] * 2008 inner London male population	Greater London Authority population estimates 2008		Greater London in 2008	men and women using computer-assisted interviews	with whom the respondent had any form of genital contact
Shields et al., 2013	United States/California/San Francisco	(Unweighted count/population estimate)*100	2011 YRBS[l]	3.8% middle school students identify as LGB[m]; 1.7% as gay and lesbian and 2.1% as bisexual	Not reported	Stratified random sample of youth	"Which of the following best describes you?" "heterosexual (straight); gay or lesbian; bisexual; and not sure"
Veierod et al., 1997	Norway	Estimated proportion of subjects with homosexual experience from 2 postal surveys of general population (Lifetime or current prevalence/number of respondents) *100	Surveys sent by mail in 1987 and 1992	3.8% reported homosexual practice during lifetime and 1.2% during the	188 lifetime; 57 past 3 years	Simple random samples drawn from the Central Population Registry,	Had any form of sexual interaction with a person of the same gender as

				past 3 years		postal questionnaires sent	yourself ever/in past 3 years
Esie et al., 2018	United States	Answers to questions and total population surveyed	NHANES 1999–2014	Estimated prevalence of MSM-ever was 5.5%	Not reported	Cross-sectional surveys of the noninstitutionalized US population	Ever had any kind of sex with a man, including oral or anal
Geary et al., 2018	Britain	Estimates from NATSAL3 were applied to ONS[n] 2011 census population estimates	NATSAL 3, ONS	1.5% of 16–74 year old men self-identified as gay; 6.5% of men reported any same-sex sexual attraction; 5.5% of men reported same-sex sex ever	Not reported	Multistage clustered, stratified probability sample of residents in a private household in Britain were interviewed	I have felt sexually attracted to…; I have had some sexual experience …; Have you ever had any kind of sexual experience or sexual contact with a man?;

							Have you had sex with a man involving genital area/penis contact?
Zablotska et al., 2018	Australia	Number of men aged 16-69 years in Australia in mid-2015 * proportion of Australian men aged 16–69 years old who identified as gay * proportion who had at least one male sex partner in the 12 months before the survey	Australian Bureau of Statistics, ASHR 2	Not reported	127,947 of sexually active 16–69 year-old gay men	National representative survey	Australian men aged 16–69 years old who identified as gay and had at least one male sex partner in the 12 months before the survey

Abbreviations:

[a]MSM-Men who have sex with men

[b]CHM-Canada Health Monitor

[c]NSFG-National Survey of Family Growth

[d]NHANES-National Health and Nutrition Examination Survey

[e]NHBS-National HIV Behavioral Surveillance

[f]HIV-Human immunodeficiency virus

[g]ASHR-Australian Study of Health and Relationships

[h]KABaSTI-Knowledge, Attitudes and Behaviour as to Sexually Transmitted Infections

[i]GMA-Gay Men and AIDS survey

[j]CCHS-Canadian Community Health Survey

[k]NATSAL-National Survey of Sexual Attitudes and Lifestyles

[l]YRBS-Youth Risk Behavior Survey

[m]LBG-Lesbian, gay, or bisexual

[n]ONS-Office of National Statistics

Table 4. Studies using census-based methods for estimating the number of men who have sex with men

Author, year	Country/State/City	Calculation	Source of data, years	Percent of MSM	Number of MSM	Sampling method	Characterization of study population
Archibald et al., 2001	Canada/Toronto, Montreal, Vancouver	Proportion of men aged 45 and over never married * census population of adult men 15 and over	Census data	Not reported	Toronto= 35,000, Montreal= 37,000, Vancouver= 26,500	Proportion of never married men obtained from census	Men aged 45 and over that have never been married
de Voux et al., 2017	United States/44 states	Percent MSM[a] =percent of male head-male unmarried partner households in county * number of men in county; scaled to equal 3.9% of adult male population	ACS[b] summary data; rural-urban classification from NCHS[c]; Purcell et al., 2012 for 3.9%	3.8% of all men overall	3,921,515 overall	ACS summary data	Households with a male head and a male partner
Lieb et al., 2009	United States/17 southern states	**Model A**: % MSM statei= (rural male population statei * 0.01) + (suburban male population statei * 0.04) + (urban male population statei * 0.09)	2000 Census, NSFG[d], ACS	6.0% in the south	2.4 million in the south 1,656,500 (69%) whites,	US Census Bureau; multi-stage area probability	Adult males who ever had sex with another male

		Model B: 1.MSM index= statei (#SSMP[e] statei/#SSMP US /(#households statei/#households US) 2. Percent MSM statei= (MSM index statei * % MSM Model A statei). 3. Average %MSMstatei= (%MSM model A statei + %MSM modelBstatei)/2. 4. Number of MSMstatei= average%MSMstatei * adult male population statei. **Model C**: RaceiMSMestimate= average % MSM statei x racei adult male population statei * % MSM ratio for racei. Model C final estimate =White MSM estimate + Black MSM estimate + Hispanic MSM estimate + Other race MSM estimate			339,400 (14%) blacks, 368,800 (15%) Hispanics, 34,600 (1.4%) Asian/Pacific Islanders, 7,700 (0.3%) American Indians/Alaska Natives, and 11,000 (0.5%) others	sample (NSFG)	
Lieb et al., 2011	United States	**Model A**: % MSM statei= (rural male population statei * 0.01) + (suburban male population statei * 0.04) +	2000 Census, NSFG, ACS	Overall US percentage of males	7.1 million MSM residing in the US in 2007;	US Census Bureau; multi-stage area probability	Adult males aged ≥18 years with a lifetime

		(urban male population statei * 0.09) **Model B:** 1.MSM index= statei(#SSMP statei/#SSMP US /(#households statei/#households US) 2. Percent MSM statei= (MSM index statei x % MSM Model A statei). 3. Average %MSMstatei= (%MSM model A statei + %MSMmodelBstatei)/2. 4. Number of MSMstatei= average%MSMstatei * adult male population statei. **Model C**: RaceiMSMestimate= average % MSM statei * racei adult male population statei * % MSM ratio for racei. Model C final estimate =White MSM estimate + Black MSM estimate + Hispanic MSM estimate + Other race MSM estimate		who were MSM was 6.4%, varied from 3.3% in South Dakota to 13.2% in the District of Columbia	ranged from 9,612 in Wyoming to 1,104,805 in California 71.4% (5.1 million) were white, 15.9% (1.1 million) were Hispanic, 8.9% (635,000) were black, 2.7% (191,000) were Asian, 0.4% (26,000) were American Indian/Alaska Native, 0.1% (6,000) were Native	sample (NSFG)	history of any male-male sexual contact

					Hawaiian/other Pacific Islander, and 0.6% (41,000) were of multiple/unknown race/ethnicity		
Campagna et al., 2015	United States/Texas/ counties	**Model A**: % MSM countyi=(rural male population countyi *0.01) + (suburban male population countyi *0.04) + (urban male population countyi * 0.09) **Model B:** 1.MSM index= countyi(#SSMP countyi/#SSMP Texas /(#households countyi/#households Texas) 2. Percent MSM countyi= (MSM index countyi * % MSM Model A countyi). 3. Average %MSMcountyi= (%MSM model A county + %MSM modelBcountyi)/2.	United States Census (2000 and 2010), ACS (2010)	6.4% of adult male population in Texas; 10.3% in Dallas; 9.8% in Austin; 1.0 to 12.9% at county level	599,683 in Texas in 2012 315,000 (53 %) Whites; 56,000 (9 %) Blacks; 213,000 (36 %) Hispanic/Latinos; 16,000 (3 %) men of other races	US Census Bureau	Households with same-sex male unmarried partners

		4. Number of MSMcountyi= average%MSMcountyi * adult male population countyi. **Model C**: RaceiMSMestimate= average % MSM countyi * racei adult male population countyi * Lieb's % MSM ratio for racei. Model C final estimate =White MSM estimate + Black MSM estimate + Hispanic MSM estimate +Other race MSM estimate					
Grey et al., 2016	United States/states/ counties	1.MSM index countyi urbanicityj= (#SSM[f] households countyi urbanicityj/total households countyi urbanicityj/(SSM households urbanicityj /total households urbanicityj) 2. Percent MSM countyi urbanicity j= (MSM index countyi urbanicityj * % MSM urbanicityj) 3. MSMcountyi urbanicity j= (%MSM countyi urbanicityj * Adult males countyi urbanicityj.	2009–2013 ACS	3.9%	4,503,080 MSM in the US	ACS 5-year summary file, 2009 to 2013, US households are randomly sampled each year	Number of same-sex male households

		4. (impute) SSM households countyi urbanicityj= SSM households countyi urbanicityj+(total households countyi urbanicityj * %SSM households urbanicityj)					

Abbreviations:

[a]MSM-Men who have sex with men

[b]ACS-American Community Survey

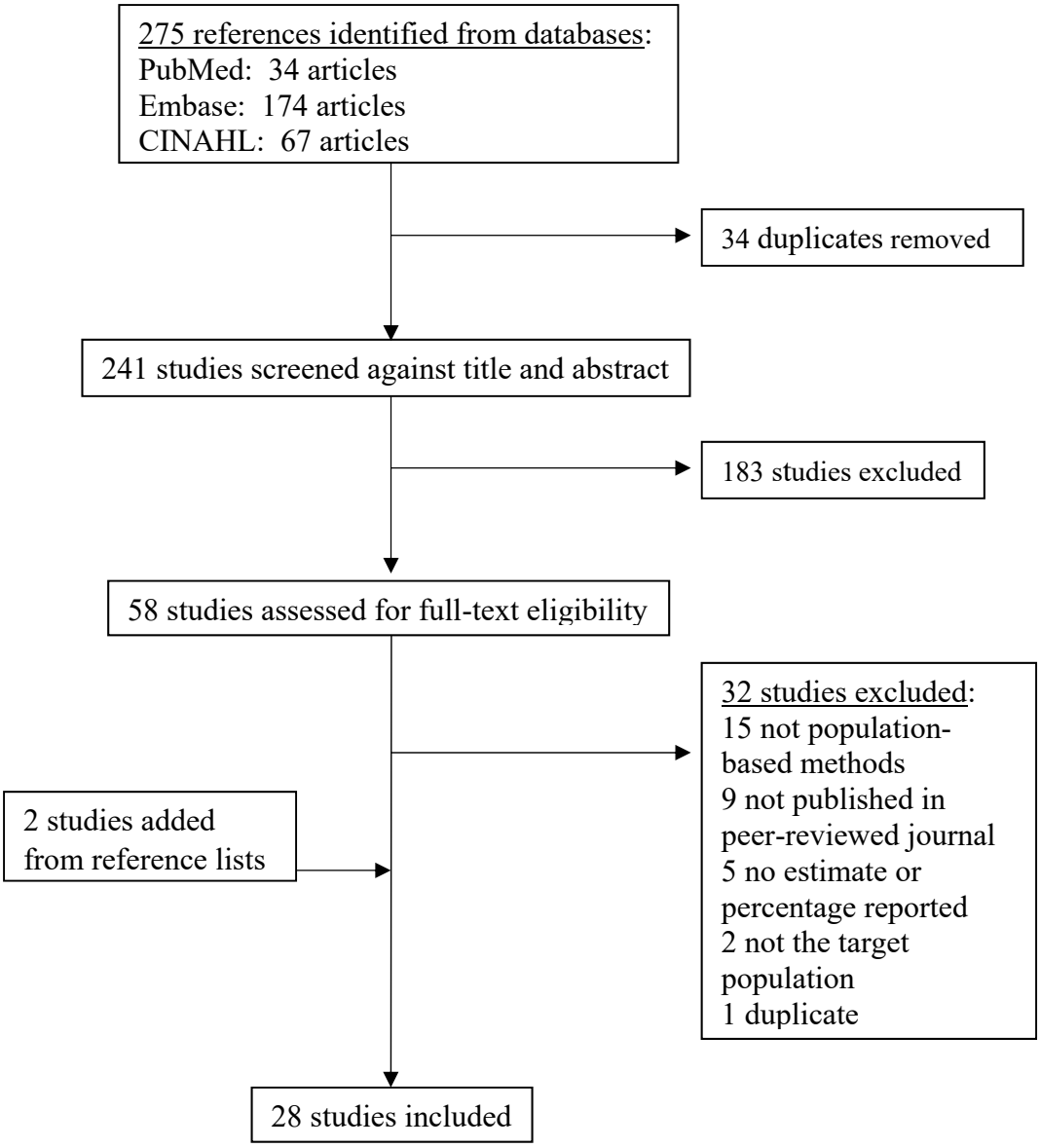
[c]NCHS-National Center for Health Statistics

[d]NSFG-National Survey of Family Growth

[e]SSMP-Same sex male partner

[f]SSM-Same sex male

Figure 1. Flowchart of screening process of studies using population-based methods for estimating the number of men who have sex with men



Manuscript 2

Gay neighborhoods: Can they be identified in a systematic way using latent class analysis?

Abstract

Identifying gay neighborhoods could help in targeting HIV prevention efforts for men who have sex with men. This study's purpose was to identify gay neighborhoods using latent class analysis (LCA). Data at the zone improvement plan (ZIP) code level was drawn from the American Community Survey, website lists of gay bars and neighborhoods, and the Florida Department of Health HIV surveillance system. A two-class model was selected based on fit. About 9% of the ZIP code data were in class two, which was designated as gay neighborhoods. Cohen's kappa coefficient was used to examine agreement between the classification of ZIP codes from LCA and websites. Fair agreement was found (0.2501). Gay neighborhoods could serve as a place to disseminate information about pre-exposure prophylaxis and other methods for HIV prevention. Improved measures, such as the planned question about same-sex spouses for the 2020 US Census, are needed to identify gay neighborhoods in population-level surveys.

Keywords: gay neighborhoods, latent class analysis, MSM, gay men

Introduction

The National HIV/AIDS Strategy strives to increase human immunodeficiency virus (HIV) prevention efforts in communities with high rates of HIV transmission and recommends focusing on high-risk populations, such as men who have sex with men (MSM) (Office of National AIDS Policy, 2015). Male-to-male sexual contact accounted for 66.6% of new HIV diagnoses in 2017 and 72% of existing HIV diagnoses at the end of 2016 in the United States (US) (CDC, 2018). Among MSM in the US, 38.4% of persons whose HIV was diagnosed in 2017 was among Black MSM while MSM aged 13–24 accounted for 25.6% (CDC, 2018). Florida was ranked third in the US for number of HIV diagnoses in 2017 (CDC, 2018). The Miami-Fort Lauderdale-West Palm Beach, FL metropolitan statistical area (MSA) had 35.3 HIV diagnoses per 100,000 per year in 2017, the highest rate in the US (CDC, 2018). Approximately 49% of all persons living with HIV in Florida in 2016 were in the Miami-Fort Lauderdale-West Palm Beach, FL MSA (CDC, 2018).

Strategies have been adopted by MSM to reduce the risk of HIV transmission (van den Boom et al., 2014). Serosorting, where MSM engage in unprotected anal intercourse with other MSM of the same HIV status, is common (van den Boom et al., 2014). This strategy is not without flaws; both partners must accurately know their status, disclose their status honestly, and should be tested frequently to be sure they have not acquired HIV (van den Boom et al., 2014). Condoms are another strategy to reduce the risk of HIV transmission. A study among MSM in San

Francisco found that the consistent use of condoms decreased from 36.8% in 2004 to 18.3% in 2014 (Chen et al., 2016). Pre-exposure prophylaxis (PrEP) is a biomedical prevention strategy to reduce the risk of HIV transmission (Jayakumaran et al., 2016). Pre-exposure prophylaxis involves the regular use of antiretroviral drugs by a person whose HIV status is negative to reduce the risk of HIV transmission from sexual contact with a person who has a diagnosis of and is living with HIV or someone of unknown HIV status (Jayakumaran et al., 2016).

Tailoring HIV prevention strategies to whether MSM live in gay neighborhood or not could be another strategy to reduce HIV transmission. Gay neighborhoods can be defined as areas within a city that foster a sense of community for gay men due to a higher proportion of homes occupied by gay men and businesses owned by or supportive of gay men (Buttram & Kurtz, 2013). The first distinct gay neighborhoods emerged after World War II when discharged members of the military settled in port cities (Spring, 2013). Bars in gay neighborhoods established social networks that made sexual minorities visible to one another and fostered a sense of community (Ghaziani, 2014). In the 1970s, researchers reported that large cities gave rise to cultural and social institutions that form the basis of gay neighborhoods (Buttram & Kurtz, 2013). The US Census Bureau has collected data on same-sex unmarried partners since 1990, which has provided data for the study of gay neighborhoods (Compton & Baumle, 2012).

The findings in the literature about risk or protective factors associated with gay neighborhood residence are varied. Some studies show that gay neighborhoods

facilitate HIV sexual risk behaviors and drug use while others show that they are protective for health (Buttram & Kurtz, 2013; Kelly et al., 2012; Carpiano et al., 2011; Frye et al., 2010). A study conducted in South Florida found that elevated rates of unprotected anal intercourse, methamphetamine use, and reduced levels of engagement in social activities were risk factors associated with living in a gay neighborhood (Buttram & Kurtz, 2013). Gay neighborhood residence was defined as residing in one of five zone improvement plan (ZIP) codes that constitute the Wilton Manors area (Buttram & Kurtz, 2013). In a study conducted in New York City, the use of drugs to enhance sexual experiences was more common among men who lived in gay neighborhoods compared to men who did not (aOR=2.08, 95% CI=1.11–3.90) (Kelly et al., 2012). Gay neighborhoods were defined using the percentage of male-male unmarried partner households and social mapping (Kelly et al., 2012). A second study conducted in New York City found higher odds of drug use among individuals who lived in gay neighborhoods, had networks composed mainly of gay men, and had increased socialization with other gay men (Carpiano et al., 2011). Gay neighborhoods were defined using the percentage of male-male unmarried partner households from census data and social mapping (Carpiano et al., 2011). Conversely, another study conducted in New York City found that neighborhood gay presence (percent of male-male unmarried partner households) was associated with consistently using condoms during insertive (adjusted odds ratio [aOR]=1.3, 95% confidence interval [CI]=1.0–1.6) and receptive anal intercourse (aOR=1.4, 95% CI=1.1–1.6) (Frye et al., 2010).

More recently, gay individuals may be choosing to live outside of historically gay neighborhoods (Spring, 2013). Historically gay neighborhoods appear to be de-concentrating as sexual minorities disperse across cities (Ghaziani, 2014). Based on the 2010 Census, fewer same-sex partners lived in historically gay neighborhoods in the 2010 than in 2000 or 1990 (Ghaziani, 2014). Many studies have used the percent of male-male unmarried partner households obtained from the census (Kelly et al., 2012; Carpiano et al., 2011; Frye et al., 2010). This is self-reported, and misclassification has been noted (O'Connell & Feliz, 2012). None of the articles that have classified neighborhoods as gay using census data has established a validated cutoff for identifying gay neighborhoods (Frye et al., 2010; Buttram & Kurtz, 2013; Kelly et al., 2012; Carpiano et al., 2011). The purpose of this study was to identify gay neighborhoods using the percent of male-male unmarried partners, the density of gay bars, and HIV prevalence data for MSM using latent class analysis (LCA). Identifying gay neighborhoods could help target high-risk individuals with HIV prevention tools, such as PrEP or treatment as prevention.

Methods

Study population and datasets

This study used an ecologic design and analyzed secondary HIV surveillance data, American Community Survey (ACS) data, and data about gay bars and gay neighborhoods from the Internet. The HIV surveillance data was obtained from the Florida Department of Health's enhanced HIV/AIDS Reporting System (eHARS).

The eHARS contains demographic and exposure information, and uses the HIV case definition from the Centers for Disease Control and Prevention (CDC) (Selik et al., 2014). De-identified records of Florida residents diagnosed with HIV with a mode of HIV transmission listed as MSM and MSM/injection drug use (IDU) were included in the dataset.

Neighborhood-level data using zone improvement plan (ZIP) code tabulation areas (ZCTAs) in Florida were obtained from the US Census Bureau's 2011–2015 ACS five-year estimates (US Census Bureau, n.d., a). The US Census Bureau uses ZCTAs to approximate US postal service ZIP codes and calculate summary statistics (US Census Bureau, n.d., b). Ninety-seven ZCTAs were excluded because they are associated with prisons, post office boxes, military bases, and nature preserves, and have no permanent residential population. Eight hundred and eighty-six Florida ZCTAs were included in this study.

A list of gay bars/clubs in a ZIP code in Florida was extracted from gaycities.com, gaybarmaps.com, and gaybarslist.com (Gay Cities, n.d.; gay bar maps, 2017; gay bars list, 2016). A list of gay ZIP codes was compiled from roadsnacks.net, movoto.com, hrc.org, sharktank.com, and orlandohomesusa.com (Roadsnacks, 2018; Movoto, n.d.; Human Rights Campaign, 2018; Sharktank, 2016, Orlando homes USA, 2017). These websites were identified using a search engine. Data from eHARS, ACS, and the gay bar/neighborhood data were merged by ZIP code.

Variables

Three variables were used to identify gay neighborhoods (1) percentage of male-male unmarried partner households, (2) density of gay bars, and (3) HIV prevalence among MSM. The percentage of male-male unmarried partner households was calculated by dividing the number of male-male unmarried partner households in a ZCTA by the total number of households in a ZCTA obtained from the 2011–2015 ACS. The percentage of male-male unmarried partner households were grouped into six categories based on percentiles of the distribution of the data ($\geq 95^{th}$ percentile, 95^{th}–90^{th}, 90^{th}–75^{th}, 75^{th}–50^{th}, 50^{th}–25^{th}, $<25^{th}$). The density of gay bars per 1,000 population in a ZIP code was calculated using the number of gay bars in each ZIP code divided by the male population in 2016 in the ZIP code. The density of gay bars was grouped into three categories based on percentiles of the distribution of the data ($\geq 95^{th}$ percentile, 95^{th}–90^{th}, and $<90^{th}$). The HIV prevalence among MSM per 1,000 population was calculated for each ZIP code. The numerator was the number of cases among MSM or MSM/IDU currently living in each ZIP code in Florida in 2016 from eHARS data. The denominator was the average male population between 2014 and 2016 in each ZIP code from the ACS. HIV prevalence was grouped into six categories based on percentiles of the distribution of the data ($\geq 95^{th}$ percentile, 95^{th}–90^{th}, 90^{th}–75^{th}, 75^{th}–50^{th}, 50^{th}–25^{th}, $<25^{th}$).

Analysis

Florida ZIP codes were the unit of analysis for this study. Latent class analysis (LCA), a statistical method used to identify a set of unobserved classes or subgroups from observed categorical variables and assess the effects of multiple variables simultaneously, was conducted using the LCA procedure in SAS 9.4 (The Methodology Center, Penn State, 2015; Chan et al., 2015; SAS Institute, 2002). First, models were run with two through five latent classes. Model fit statistics (Akaike Information Criterion [AIC], Bayesian Information Criterion [BIC], and entropy) were examined to determine the optimal number of classes to include (Chan et al., 2015). With AIC and BIC, lower values indicate better fit (Chan et al., 2015). Entropy indicates how distinct or separate the classes are from one another (Chan et al., 2015). Entropy ranges from zero to one, with above 0.8 considered as good (Chan et al., 2015). Next, the classes were assessed to determine which could be classified as gay or not gay. Finally, Cohen's kappa coefficient was used to look at agreement between the classification of ZIP codes from the LCA and websites. Cohen's kappa coefficient ranges from negative one to positive one (McHugh, 2012). For interpreting kappa, values less than or equal to zero indicate no agreement, 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement (McHugh, 2012). The hypothesis was that the ZIP codes obtained through the LCA would agree with the gay ZIP codes from websites. The Florida International University Institutional Review Board (IRB) and the Florida Department of Health IRB approved this study.

Results

Description of the data

Within the 886 ZIP codes in Florida used in this study, the percent male-male unmarried partner households in a ZIP code ranged from 0.0 to 6.2% (Table 1). Thirty-seven ZIP codes had more than 1% male-male unmarried partner households. The number of gay bars in a ZIP code ranged from zero to 15, and the density ranged from zero to 2.9 bars per 1,000 male population (Table 1). Ninety-four ZIP codes had at least one gay bar. HIV prevalence among MSM per 1,000 population for ZIP codes ranged from 0.18 to 144.90, with 5% of the ZIP codes being within the two highest categories for HIV prevalence (HIV prevalence of 10.45–<16.59 and 16.59–144.90, respectively) (Table 1).

Latent class analysis

The model fit statistics indicated that a two-class model had the best fit. The BIC was lowest (341.62) for the two-class model indicating the best fit and was 350.53, 414.06, and 487.81 for the three-class, four-class, and five-class models respectively. Entropy was highest (0.90) for the two-class model, indicating better fit of the data and was 0.62, 0.65, and 0.63 for the three-class, four-class, and five-class models respectively. The AIC was 221.95 for the two-class model, 168.84 for the three-class model (lowest), 169.94 for the four-class model, and 181.46 for the five-class model. Entropy for the other class models was less than 0.80, therefore, the two-class model was chosen.

About 91% of ZIP codes in Florida fell into class one (not gay) and 9% fell into class two (gay) (Table 2). Among not gay neighborhoods, around 41% of ZIP codes fell into the lowest category (0%) for percent of male-male unmarried partner households (Table 2). For the density of gay bars in not gay neighborhoods, 95.6% of ZIP codes fell into the lowest category (<0.04 bars per 1,000 male population) (Table 2). For HIV prevalence among MSM, 27% of ZIP codes went into each of the three lowest categories for not gay neighborhoods (<1.19, 1.19–<2.92, and 2.92–<5.26 per 1,000, respectively) (Table 2).

Of the Florida ZIP codes, 9% fell into class two (gay) (Table 2). About 36% fell into the highest category (0.91–<6.2%) for percent male-male unmarried partner households in gay neighborhoods (Table 2). Approximately 47% of ZIP codes fell into the highest category (0.12–<2.98 bars per 1,000) for density of gay bars in gay neighborhoods (Table 2). The highest percentage of ZIP codes were in the two highest categories of HIV prevalence among MSM (16.59–<144.90 per 1,000 and 10.45–<16.59 per 1,000), which was 49.6% and 26.5%, respectively (Table 2).

Comparison with neighborhoods identified through LCA and websites

From the LCA, 818 ZIP codes were classified into class one (not gay) and 68 into class two (gay) (Table 3). From websites, 834 ZIP codes were identified as not gay and 52 as gay (Table 3). Of the 52 ZIP codes identified from the websites as gay, 18 (34.6%) were also identified in the LCA (Table 3). The Cohen's kappa coefficient between these two measures was 0.2501, indicating fair agreement.

Of the 68 gay ZIP codes identified by the LCA, 27 (39.7%) were in the highest category of percent male-male unmarried households, 37 (54.4%) were in the highest category of density of gay bars, and 41 (60.3%) were in the highest category of HIV prevalence among MSM (data not shown). Of the 52 gay ZIP codes from the websites, 11 (21.2%) were in the highest category of percent male-male unmarried households, 12 (23.1%) were in the highest category of density of gay bars, and 14 (26.9%) were in the highest category of HIV prevalence among MSM (data not shown).

Discussion

In this study, gay neighborhoods were identified in Florida using latent class analysis with three variables: percent male-male unmarried partner households, density of gay bars, and HIV prevalence among MSM. This study used a residential measure of gay neighborhoods (percent of male-male unmarried partner households) as in studies by Kelly et al. (2012), Carpiano et al. (2011), and Frye et al. (2010), and added a social measure (density of gay bars) plus a second residential measure (HIV prevalence among MSM). The LCA revealed two classes in the data with class two (gay neighborhoods) including 9% of ZIP codes. Overall, there was little agreement between the ZIP codes from the LCA and ZIP codes identified from websites (0.2501), or between each of the variables. Of note, Wilton Manors and Miami Beach are well-known historically gay neighborhoods in Florida and the ZIP codes associated with these areas were correctly placed in class two (gay) by the LCA. Additionally, Wilton Manors was listed in the websites.

Limitations

Identifying gay neighborhoods is challenging due to conceptualization of gay neighborhoods and problems inherent to the measures. First, gay individuals may be choosing to live outside of historically gay neighborhoods, contributing to their de-concentration as sexual minorities disperse across cities (Spring, 2013; Ghaziani, 2014). Based on the 2010 census, fewer same-sex partners lived in historically gay neighborhoods in 2010 than in 2000 or 1990 (Ghaziani, 2014). Second, ZIP codes are a relatively large geographic area. Unfortunately, HIV prevalence by census tract was not available for this analysis, but even census tracts may have been too large an area. Census tracts contain up to 8,000 people while ZIP codes can exceed 100,000 people (Proximity one, 2019). Third, no research has come up with established and validated cutoffs for classifying neighborhoods as gay versus not gay using census data (Kelly et al., 2012; Carpiano et al., 2011; Frye et al., 2010). Fourth, two of the measures are based on with residence (i.e., male-male unmarried households and HIV prevalence) and one on entertainment (gay bars). People do not necessarily socialize in the same ZIP code where they live (Vaughan et al., 2017). The LCA was attempted using just the two residential variables, but the entropy was unacceptably low (0.61). Fifth, trying to identify gay neighborhoods through websites is problematic. Some websites listed entire metropolitan areas as gay. Metropolitan areas were excluded from the list of gay ZIP codes from websites because it is unlikely that all ZIP codes in a metropolitan area are gay. Therefore, the website list of gay ZIP codes used in this study may not be comprehensive.

Conclusions

This study used LCA to identify gay neighborhoods at the ZIP code level in Florida using the percent of male-male unmarried partner households, density of gay bars, and HIV prevalence among MSM. Gay neighborhoods identified through LCA had fair agreement with information obtained from websites. Men who live in gay neighborhoods could be at increased risk of engaging in a subculture that promotes unhealthy activities or risk taking (Kelly et al., 2012). Lesbian, gay, bisexual, and transgender individuals experience unique forms of stress due to discrimination, which can have a negative effect on mental and physical health (Frost, Meyer, & Schwartz, 2016). This stress could be lower in gay neighborhoods due to less discrimination. Historically gay neighborhoods, such as Wilton Manors or Miami Beach in Florida, could be a place to direct prevention resources and offer information about PrEP and treatment as prevention to achieve viral suppression. Social networks in gay neighborhoods could also be used to promote health. The US Census Bureau is planning to ask questions about same-sex spouses in addition to unmarried partners in the 2020 Census and the American Community Survey (US Census Bureau, 2018). Future studies could use these questions to get a more complete picture of gay neighborhoods.

References

Buttram ME & Kurtz SP. Risk and Protective Factors Associated With Gay Neighborhood Residence. *Am J Mens Health*. 2013;7(2):110–118.

Carpiano RM, Kelly BC, Easterbrook A, Parsons JT. Community and drug use among gay men: The role of neighborhoods and networks. *J Health Soc Behav*. 2011;52(1):74–90.

Centers for Disease Control and Prevention. HIV Surveillance Report, 2017; vol. 29; 2018. Available at: https://www.cdc.gov/hiv/pdf/library/reports/surveillance/cdc-hiv-surveillance-report-2017-vol-29.pdf.

Chan PA, Rose J, Maher J, et al. A latent class analysis of risk factors for acquiring HIV among men who have sex with men: Implications for implementing pre-exposure prophylaxis programs. *AIDS Patient Care STDs*. 2015;29(11):597–605.

Chen Y, Snowden JM, McFarland W, Raymond HF. Pre-exposure Prophylaxis (PrEP) Use, Seroadaptation, and Sexual Behavior Among Men Who Have Sex with Men, San Francisco, 2004–2014. *AIDS Behav*. 2016;20(12):2791–2797.

Compton DR & Baumle AK. Beyond the Castro: The role of demographics in the selection of gay and lesbian enclaves. *J Homosex*. 2012;59(10):1327–1355.

Florida Lesbian and Gay Bars, Restaurants, Lodging, Pride Event, Business Maps. 2017. Available at https://www.gaybarmaps.com/bars/florida.

Frost DM, Meyer EH, Schwartz A. Social support networks among diverse sexual minority populations. *Am J Orthopsychiatry*. 2016;86(1):91–102.

Frye V, Koblin B, Chin J, et al. Neighborhood-level correlates of consistent condom use among men who have sex with men: A multi-level analysis. *AIDS Behav*. 2010;14(4):974–985.

GayCities - Gay bars, hotels, restaurants with reviews, maps, photos. No date. Available at http://www.gaycities.com/

Gay bars list: Directory listing of gay, lesbian, transsexual, and bisexual bars in the USA-Florida. 2016. Available at http://www.gaybarslist.com/FL.htm

Ghaziani A. Measuring urban sexual cultures. *Theory Soc*. 2014;43(3-4):371–393.

Human Rights Campaign Municipal Equality Index. 2018. Available at https://assets2.hrc.org/files/assets/resources/MEI-2018-FullReport.pdf.

Jayakumaran JS, Aaron E, Gracely EJ, et al. Knowledge, Attitudes, and Acceptability of Pre-Exposure Prophylaxis among Individuals Living with HIV in an Urban HIV Clinic. *PLOS One*. 2016;11(2):e0145670.

Kelly BC, Carpiano RM, Easterbrook A, Parsons JT. Sex and the community: The implications of neighbourhoods and social networks for sexual risk behaviours among urban gay men. *Sociol Health Illn*. 2012;34(7):1085–1102.

McHugh ML. Interrater reliability: The kappa statistic. *Biochem Med*. 2012;22(3):276–282.

Movoto The 6 Best Towns in Florida for LGBT Families. No date. Available at https://www.movoto.com/guide/fl/the-6-best-towns-in-florida-for-lgbt-families/.

Office of National AIDS Policy. National HIV/AIDS Strategy Updated to 2020. 1–65. 2015. Available at https://www.hiv.gov/federal-resources/national-hiv-aids-strategy/overview/.

O'Connell M, Feliz S. Same-sex Couple Household Statistics from the 2010 Census. Bureau of the Census. 2011. Available at: https://www.census.gov/library/working-papers/2011/demo/SEHSD-WP2011-26.html.

Orlando Homes USA. Orlando Area Top Gayborhoods. 2017. Available at https://www.orlandohomesusa.com/orlando-gayborhoods.

PROC LCA & PROC LTA (Version 1.3.2). University Park: The Methodology Center, Penn State. 2015. Available at: http://methodology.psu.edu

Proximity one. 10 Reasons to use Census Tract Versus ZIP Code, Geography & Demographics. 2019. Available at http://proximityone.com/tracts_zips.htm.

Roadsnacks- These Are The 10 Gayest Places In Florida For 2019. 2018 Available at https://www.roadsnacks.net/gayest-places-in-florida/.

SAS Institute, Cary, NC. 2002. Available at https://www.sas.com/en_us/software/sas9.html.

Selik RM, Mokotoff ED, Branson B, Owen SM, Whitmore S, Hall HI. Revised surveillance case definition for HIV infection—United States, 2014. *MMWR Recomm Rep*. 2014;63(RR-03):1–10.

Sharktank Florida's top gay cities are…You will be surprised. 2016. Available at https://shark-tank.com/2016/10/24/floridas-top-gay-cities-are-you-will-be-surprised/

Spring AL. Declining segregation of same-sex partners: Evidence from Census 2000 and 2010. *Popul Res Policy Rev*. 2013;32(5):687–716.

US Census Bureau. American fact finder. Washington, DC: Government Printing Office. No date (a). Available at http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.

US Census Bureau. ZIP code TM tabulation areas (ZCTA™). Washington, DC: Government Printing Office. No date (b). Available at http://www.census.gov/geo/reference/zctas.html.

US Census Bureau. Questions Planned for the 2020 Census and American Community Survey. 2018. Available at

https://www.census.gov/library/publications/2018/dec/planned-questions-2020-acs.html.

van den Boom W, Konings R, Davidovich U, et al. Is serosorting effective in reducing the risk of HIV-infection among men who have sex with men with casual sex partners? *J Acquir Immune Defic Syndr*. 2014;65(3):375–379.

Vaughan AS, Kramer MR, Cooper HLF, Rosenberg ES, Sullivan PS. Activity spaces of men who have sex with men: An initial exploration of geographic variation in locations of routine, potential sexual risk, and prevention behaviors. *Soc Sci Med*. 2017;175:1–10.

Tables and figures

Table 1. Distribution of ZIP codes among levels of percent male-male households, density of gay bars and HIV prevalence among men who have sex with men, Florida

	Percentile of ZIPs[a]	Number of ZIP codes (%)
Percent male-male households 2011–2015		
0.91–<6.2	≥95%	44 (5.0)
0.66–<0.91	≥90–<95%	44 (5.0)
0.34–<0.66	≥75–<90%	134 (15.1)
0.14–<0.34	≥50–<75%	221 (24.9)
>0–<0.14	≥25–<50%	107 (12.1)
0, lowest	<25%	336 (37.9)
Density of gay bars (number bars per 1,000 male population)		
0.12–2.98, high	≥95%	45 (5.1)
0.04–<0.12, moderate	≥90–<95%	44 (5.0)
<0.04, low	<90%	797 (90.0)
HIV[b] prevalence among MSM[c] in 2016 (number cases per 1,000 male population)		
16.59–144.90, highest	≥95%	43 (4.9)
10.45–<16.59	≥90–<95%	45 (5.2)
5.26–<10.45	≥75–<90%	130 (14.9)
2.92–<5.26	≥50–<75%	217 (24.9)
1.19–<2.92	≥25–<50%	219 (25.1)
<1.19, lowest	<25%	217 (24.9)

Abbreviations:

[a]ZIP, zone improvement plan

[b]HIV, human immunodeficiency virus

[c]MSM, men who have sex with men

Table 2. Distribution of categories for male-male households, density of gay bars and HIV prevalence among men who have sex with men in each latent class, Florida

	Class 1 (percentage of ZIP codes in category)	Class 2 (percentage of ZIP codes in category)
Percent of ZIP[a] codes	0.9099	0.0901
Percent male-male households 2011–2015		
0.91–<6.2, highest	0.0186	0.3613
0.66–<0.91	0.0416	0.1309
0.34–<0.66	0.1395	0.2693
0.14–<0.34	0.2591	0.1527
>0–<0.14	0.1273	0.0554
0, lowest	0.4140	0.0305
Density of gay bars per 1,000 male population	0.0090	0.4706
0.12–2.98, high	0.0353	0.1943
≥0.04–<0.12, moderate	0.9558	0.3352
<0.04, low		
HIV[b] prevalence among MSM[c] in 2016 (number cases per 1,000 male population)		
16.59–144.90, highest	0.0040	0.4962
10.45–<16.59	0.0300	0.2652
5.26–<10.45	0.1468	0.1733
2.92–<5.26	0.2686	0.0575
1.19–<2.92	0.2765	0.0046
<1.19, lowest	0.2741	0.0032

Abbreviations:

[a]ZIP, zone improvement plan

[b]HIV, human immunodeficiency virus

[c]MSM, men who have sex with men

Table 3. Comparison of ZIP codes identified from latent class analysis and websites, Florida

	Websites Not Gay (column percent)	Websites Gay (column percent)	Total
LCA[a] class 1 (not gay)	784 (94%)	34 (65.4%)	818
LCA class 2 (gay)	50 (6%)	18 (34.6%)	68
Total	834	52	886

Abbreviations:

[a]LCA, latent class analysis

Manuscript 3

Estimating the size of HIV-negative MSM population that would benefit from pre-exposure prophylaxis in Florida

Abstract

This study aimed to estimate the size of the population of men who have sex with men (MSM) in Florida with high-risk behaviors that would indicate eligibility for pre-exposure prophylaxis (PrEP) use. Three methods were used to estimate the MSM population in Florida. Estimates from the three methods were averaged, and the number of MSM living with HIV in each zone improvement plan (ZIP) code was subtracted. The average MSM estimate was 1–2,184 men (1.5–22.9%) by ZIP code. The size of the MSM population with indications for potential PrEP use was highest when using estimates of MSM with more than one sex partner in the past year obtained from the National HIV Behavioral Surveillance system and lowest when the MSM estimate was multiplied by 24.7% (percent of MSM with PrEP indications from other studies). Areas with high numbers of MSM with PrEP indications could be targeted with information to reduce HIV acquisition.

Keywords: MSM, population estimation, ZIP code, PrEP

Introduction

Florida was third in the United States (US) for HIV diagnosis rates in 2017 (including Washington, DC) (CDC, 2018). In Florida in 2017, 63% of persons who received a new HIV diagnosis were men who have sex with men (MSM) and 54% of those living with an HIV diagnosis were MSM (Florida Department of Health, 2019).

Men who have sex with men can be at high risk for HIV, but accurate estimates of the size of this population are hard to obtain because census systems typically do not ask about sexual behavior or attraction (Wesson et al., 2017; Purcell et al., 2012). Challenges include stigma concerns and measurement issues, which can limit study of sexual orientation domains (e.g. behavior, identity, or attraction) (Wesson et al., 2017; Purcell et al., 2012). Population-based methods use the size of the general population combined with percentages of men reporting same-sex experience, attraction, or identity from national health surveys, and male-male unmarried partner household data from the US Census Bureau to produce MSM population estimates (Wesson et al., 2017; Grey et al., 2016).

Rural MSM may face barriers to accessing HIV prevention services and treatment more than those living in urban areas (Hubach et al., 2017). A recent study indicated that MSM in rural areas do not believe HIV is a local threat and do not engage in HIV risk reduction (Hubach et al., 2017). Additionally, MSM who live in rural areas may have limited access to newer HIV prevention tools, such as pre-exposure prophylaxis (PrEP) (Hubach et al., 2017).

Pre-exposure prophylaxis was approved by the Federal Drug Administration in 2012 and has been shown, if used daily, to reduce HIV transmission by 92%. In 2014, the US Public Health Services released guidelines for PrEP use among high-risk groups (US Public Health Service, 2014). The National HIV/AIDS Strategy and the Ending the Epidemic Plan strive to increase HIV prevention efforts among high-risk populations, such as MSM and expand access to effective prevention services,

such as PrEP (Office of National AIDS Policy, 2015; Fauci et al., 2019). Since MSM bear the burden of HIV diagnoses across the nation, it is beneficial to assess the size of the at-risk MSM population and their geographic distribution so that prevention programs can be tailored towards MSM. This purpose of this study is to estimate the size of the MSM population in Florida with indications for PrEP use.

Methods

Study population and datasets

Data from Florida's enhanced HIV/AIDS Reporting System (eHARS) were used to obtain the number of people living with an HIV diagnosis whose mode of transmission was MSM or MSM and injection drug use (IDU) by ZIP code. The 2011–2015 American Community Survey (ACS) was used to obtain neighborhood-level data using ZIP codes in Florida (US Census Bureau, n.d.). Rural-urban status of ZIP codes was obtained from the University of Washington and was based on categorization C of Version 2.0 Rural-Urban Categorization data codes (WWAMI Rural Health Research Center, n.d.). Data from eHARS and neighborhood-level data were merged by ZIP code.

Estimation of the MSM population

The size of the MSM population in each ZIP code was estimated using three methods. The first used the number of male-male unmarried partner households in the ZIP code obtained from the ACS (US Census Bureau, n.d.). The second method multiplied the expected proportion of MSM among men (3.9% from Purcell et al.,

2012) by the number of men aged 15 and older according to the 2015 ACS (Purcell et al., 2012; US Census Bureau, n.d.). The third method is an adaptation of Lieb et al. (2009) method where more recent data were used (2011–2015 ACS and 2011–2015 National Survey of Family Growth) (US Census Bureau, n.d.; CDC, 2017a). The calculation can be found in Supplementary Table 1.

The number of MSM calculated from these three approaches were averaged for each ZIP code to provide an estimate of the MSM population in Florida. The number of men with a mode of HIV transmission listed as MSM or MSM/injection drug users (IDU) (from eHARS) in a ZIP code were subtracted from the average MSM estimate to obtain the number of presumed HIV-negative MSM.

Indications for PrEP

Smith et al. (2015) proposed a method to estimate the number of persons with indications for PrEP among MSM using the 2014 guidelines from the US Public Health Service and data from the National Health and Nutrition Examination Survey (NHANES) (Smith et al., 2015; US Public Health Service, 2014). The method entails estimating the number of MSM who have not been diagnosed with HIV, the number having sex with two or more men in the past twelve months, and the number with at least one of the following: a) any reported condomless sex in the past twelve months, b) sexually transmitted infection diagnosis in the past twelve months, or c) HIV status of partners that could not be established (Smith et al., 2015). This resulted in 24.7% (Smith et al., 2015). In the present study, the estimated number of presumed HIV-negative MSM in Florida were multiplied by the percent for each indication from the

National HIV Behavioral Surveillance System (NHBS) (CDC, 2014). The percentages from NHBS were 77%, 57%, 8.8%, and 39%, respectively (CDC, 2014). The results were then compared with those from Smith et al. (2015).

Analysis

The estimates of the average number of MSM, of presumed HIV-negative MSM, and of PrEP eligible MSM by ZIP code were divided by the number of adult males in each ZIP code to obtain a percentage. This process was repeated for rural/urban status and county. The Florida International University Institutional Review Board (IRB) and Florida Department of Health IRB approved this study.

Results

Estimation of the MSM population in Florida

Ninety-seven ZIP codes were excluded because they have no permanent residential population, leaving 886 for analysis. The three methods, data sources, calculations, and range of estimates are listed in Table 1. When the three methods were averaged, the range of MSM was 1–2,184 men with a median of 259 men (Table 1). The number of presumed HIV-negative MSM in a ZIP code ranged from 1–1,346 men, with a median of 219 (Table 1).

Table 2 depicts the estimates for the ZIP codes, rural/urban areas, counties, and the state. The largest estimate was obtained for MSM with more than one sex partner in the past year (PrEP indication 1; 166,577 for the state). The estimate obtained using the percent of MSM with PrEP indications obtained from NHANES

(24.7%) was 67,226, approximately half of the estimate using just PrEP indication 1 obtained using the prevalence of indications obtained from NHBS (Table 2). The average MSM estimate, presumed HIV-negative MSM estimate, and estimates for PrEP indications were higher in urban than rural areas (Table 2).

Discussion

Three methods were used to estimate the MSM population in Florida, which can reduce variability of using a single method. Three other studies have estimated MSM in Florida, but not at the ZIP code level or by presumed HIV-negative and PrEP eligible MSM. One study estimated MSM in the Miami metropolitan statistical area (MSA) and the others were at the state level (Lieb et al., 2007; Lieb et al., 2009; Lieb et al., 2011). Each of these studies found that approximately seven percent of men in Florida were MSM (Lieb et al., 2007; Lieb et al., 2009; Lieb et al., 2011). The current study found that 1.5–22.9% of men were MSM by ZIP code.

Three studies have estimated MSM who are eligible for PrEP using a national estimate (Smith et al., 2015; Smith et al., 2018; Donnely et al., 2019). Smith et al. (2015) used NHANES data to estimate the percentage of MSM with indications for PrEP (Smith et al., 2015). Smith et al. (2018) used an estimate of MSM at the state level from Grey et al. (2016) (Smith et al., 2018). Donnely et al. (2019) estimated MSM with PrEP indications by counties in Colorado (Donnely et al., 2019). The present study differed from these others in that it directly estimated MSM in Florida ZIP codes using three methods and data on PrEP indications were derived from NHBS. This yielded a higher percent of MSM with behavioral indications for PrEP

use than the estimate used by Smith et al (24.7%) which is based on NHANES data. Participants for the MSM cycle of NHBS are recruited from venues frequented by MSM such as bars and clubs (CDC, 2019). The NHANES survey examines a nationally representative sample selected at random (CDC, 2017b). Thus, NHBS may overestimate PrEP indications among the general MSM population.

Limitations

This study used survey and ACS data to estimate the size of the MSM population, which are subject to limitations. Survey methods can have small sample sizes, which may result in a broad range when the behavior is rare (Archibald et al., 2001). The questions used to identify MSM or recall periods may not be consistent across surveys, and people may be reluctant to self-report sensitive behaviors due to stigma (Archibald et al., 2001; Purcell et al., 2012). This study used data on men with an HIV transmission mode listed as MSM or MSM/IDU. This transmission mode could be underreported due to stigma towards same-sex behavior (Glick & Golden, 2010). A study from 2010 found that MSM with unfavorable attitudes towards homosexuality were less likely to report ever having an HIV test than MSM with more favorable attitudes (Glick & Golden, 2010). National estimates were applied to ZIP code data for the Purcell method and PrEP indications. These may not be representative of small geographic units and MSM could vary by location (Purcell et al., 2012; Grey et al., 2016). Error in classification of male-male unmarried partner households has been reported, which could affect the accuracy of the ACS estimates (O'Connell & Feliz, 2011).

Conclusions

Estimating the MSM population could help in the design and implementation of programs to reduce new HIV infections in Florida Areas with high numbers of MSM or PrEP eligible MSM could be targeted with information on HIV testing and PrEP to prevent HIV infection. Having these estimates could help track progress towards goals of the National HIV/AIDS Strategy and the Ending the Epidemic Plan to reduce new HIV infections and expand access to prevention services, such as PrEP. Future studies could look at awareness and uptake of PrEP using the estimate of PrEP eligible MSM.

References

Archibald CP, Jayaraman GC, Major C, et al. Estimating the size of hard-to-reach populations: a novel method using HIV testing data compared to other methods. *AIDS.* 2001;15(Suppl 3):s41–48.

Centers for Disease Control and Prevention. HIV Risk, Prevention, and Testing Behaviors—National HIV Behavioral Surveillance System: Men Who Have Sex With Men, 20 US Cities, 2011. HIV Surveillance Special Report 8. 2014. Available at: https://www.cdc.gov/hiv/library/reports/hiv-surveillance-archive.html#special-archive.

Centers for Disease Control and Prevention. NSFG 2011-2015 Key statistics. 2017(a). Available at: https://www.cdc.gov/nchs/nsfg/key_statistics/s.htm#sexualmales.

Centers for Disease Control and Prevention. About the National Health and Nutrition Examination Survey. 2017(b). Available at: https://www.cdc.gov/nchs/nhanes/about_nhanes.htm.

Centers for Disease Control and Prevention. HIV Surveillance Report, 2017; vol. 29. 2018. Available at: https://www.cdc.gov/hiv/pdf/library/reports/surveillance/cdc-hiv-surveillance-report-2017-vol-29.pdf.

Centers for Disease Control and Prevention. National HIV Behavioral Surveillance. 2019. Available at: https://www.cdc.gov/hiv/statistics/systems/nhbs/index.html.

Donnely JA, Deem TT, Duffy MA, et al. Applying National Estimates of Adults With Indications for Pre-Exposure Prophylaxis to Populations of Men Who Have Sex With Men and People Who Inject Drugs in Colorado: Modeling Study. *JMIR Public Health Surveill*. 2019; 5(1):e11113.

Fauci AS, Redfield RR, Sigounas G, et al. Ending the HIV epidemic: A plan for the United States. *JAMA*. 2019;321(9):844–845.

Florida Department of Health. MSM fact sheet. 2019. Available at: http://www.floridahealth.gov/diseases-and-conditions/aids/surveillance/fact-sheet1.html.

Garcia M, Harris AL. PrEP awareness and decision-making for Latino MSM in San Antonio, Texas. *PLOS One*. 2017;12(9):e0184014.

Glick SN, Golden MR. Persistence of racial differences in attitudes toward homosexuality in the United States. *J Acquir Immune Defic Syndr*. 2010;55(4):516–523.

Grey JA, Bernstein KT, Sullivan PS, et al. Estimating the population sizes of men who have sex with men in US states and counties using data from the American Community Survey. *JMIR Public Health Surveill.* 2016;2(1):e14.

Hubach RD, Currin JM, Sanders CA, et al. Barriers to access and adoption of pre-exposure prophylaxis for the prevention of HIV among men who have sex with men (MSM) in a relatively rural state. *AIDS Educ Prev*. 2017:29(4):315–359.

Lieb S, Trepka MJ, Thompson DR, et al. Men who have sex with men: estimated population sizes and mortality rates by race/ethnicity, Miami-Dade County, Florida. *J Acquir Immune Defic Syndr.* 2007;46(4):485–490.

Lieb S, Thompson, DR, Misra S, et al. Estimating populations of men who have sex with men in the Southern United States. *J Urban Health*. 2009;86(6):887–901.

Lieb S, Fallon SJ, Friedman SR, et al. Statewide estimation of racial/ethnic populations of men who have sex with men in the US. *Public Health Rep.* 2011;126(1):60–72.

Office of National AIDS Policy. National HIV/AIDS Strategy Updated to 2020. 1–65. 2015. Available at: https://www.hiv.gov/federal-response/national-hiv-aids-strategy/overview/.

O'Connell M, Feliz S. Same-sex couple household statistics from the 2010 Census. Bureau of the Census. 2011. Available at: https://www.census.gov/library/working-papers/2011/demo/SEHSD-WP2011-26.html.

Purcell DW, Johnson CH, Lansky A, et al. Estimating the population size of men who have sex with men in the United States to obtain HIV and syphilis rates. *Open AIDS J*. 2012;6:98–107.

Smith DK, Van Handel M, Wolitski RJ, et al. Vital signs: Estimated percentages and numbers of adults with indications for preexposure prophylaxis to prevent HIV acquisition--United States, 2015. *J Miss State Med Assoc*. 2015;56(12):364–371.

Smith DK, Van Handel M, Grey J. Estimates of adults with indications for HIV pre-exposure prophylaxis by jurisdiction, transmission risk group, and race/ethnicity, United States, 2015. *Ann Epidemiol*. 2018;28(12):850–857.

US Census Bureau. American fact finder. Washington, DC: Government Printing Office. No date. Available at: http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.

US Public Health Service, Preexposure prophylaxis for the prevention of HIV infection in the United States – 2014. 2014. Available at: https://www.cdc.gov/hiv/pdf/PrEPguidelines2014.pdf.

Wesson P, Reingold A, McFarland W. Theoretical and empirical comparisons of methods to estimate the size of hard-to-reach populations: a systematic review. *AIDS Behav.* 2017;21(7):2188–2206.

WWAMI Rural Health Research Center. Rural-Urban Commuting Areas (RUCA). No date. Available at: http://depts.washington.edu/uwruca/ruca-uses.php.

Tables and figures

Table 1. Methods and estimates of the population of men who have sex with men in Florida.

Method	Data source	Calculation	Median of estimate for ZIP code (range)
Male-male unmarried partners	2011–2015 ACS[a]	Number of male-male unmarried partners	11 (0–540)
Purcell et al.	3.9% from Purcell et al., 2012, men 15 and older from 2011–2015 ACS	0.039 * men 15 and older in ZIP code	312 (3–1,216)
Lieb et al.	2010 census, 2011–2015 ACS, 2011–2015 National Survey of Family Growth	Model A: %MSM ZIP[b]= (rural male population ZIP * 0.01) + (suburban male population ZIP * 0.04) + (urban male population ZIP * 0.09) Model B: 1.MSM index= ZIP (#SSMP[c] ZIP/#SSMP state /(#households ZIP/#households state) 2. Percent MSM ZIP= (MSM index ZIP * % MSM Model A ZIP). 3. Average %MSM ZIP= (%MSM model A ZIP + %MSM model B ZIP)/2. 4. Number of MSM ZIP= average%MSM ZIP * adult male population ZIP	437 (0–5,490)
Average of male-male unmarried partners, Purcell, and Lieb		(Male-male unmarried partners estimate + Purcell estimate + Lieb estimate)/3	259 (1–2,184)

HIV[d] negative MSM[e]	Average estimate, Florida Department of Health for HIV positive	Average estimate – HIV positive MSM	219 (1–1,346)

Abbreviations:

[a]ACS, American Community Survey

[b]ZIP, zone improvement plan

[c]SSMP, same-sex male partner

[d]HIV, human immunodeficiency virus

[e]MSM, men who have sex with men

[f]PrEP, pre-exposure prophylaxis

Table 2. Estimates of the percentage of the population of men who have sex with men in Florida

	ZIP[a] code median, (range, %)	Rural-urban status of ZIP code	County	State estimate (%)
Average MSM[b] estimate	259 (1–2,184, 1.5–22.9%[e])	rural: 1.5–7.4% urban: 1.5–22.9%	1,849 (130–30,118, 1.6–5.2%)	272,171 (3.6%)
HIV[c] positive MSM	29 (1–1,782, 0.7–99.8%)	rural: 1.1–96.8% urban: 0.7–99.8%	191, (15–13,482, 2–79.5%	55,838 (20.5%)[k]
HIV negative MSM	219 (1–1,376, 0.02–12.7%)	rural: 0.05–5.6% urban: 0.02–12.7%	1,562 (58–24,695, 0.8–3.8%)	216,334 (2.9%)
HIV negative MSM * PrEP[d] indication 1[f]	168 (0–1,037, 0–9.8%)	rural: 0–5.1% urban: 0–9.7%	1,202 (45–19,015, 0.3–5.9%)	166,577 (2.2%)
HIV negative MSM * PrEP indication 2[g]	124 (0–767, 0–7.2%)	rural: 0–3.7% urban: 0–7.2%	890 (32–14,076, 0.2–4.4%)	123,310 (1.6%)
HIV negative MSM * PrEP indication 3[h]	19 (0–119, 0–1.1%)	rural: 0–0.6% urban: 0–1.1%	137 (5–2,173, 0.04–0.7%)	19,037 (0.3%)
HIV negative MSM * PrEP indication 4[i]	85 (0–525, 0–4.9%)	rural: 0–2.6% urban: 0–4.9%	609 (23–9,631, 0.2–3.0%)	84,370 (1.1%)
Average MSM estimate * 0.247[j]	64 (0–540, 0.4–5.7%)	rural: 0.4–1.8% urban: 0.4–5.7	457 (32–7,439, 0.4–4.7%)	67,226 (0.9%)

Abbreviations:

[a]ZIP, zone improvement plan

[b]MSM, men who have sex with men

[c]HIV, human immunodeficiency virus

[d]PrEP, pre-exposure prophylaxis

Notes:

[e]Percentages obtained by dividing estimate by male population over 18 from ACS 2011–2015

[f]MSM with negative or unknown HIV status in the US who reported having more than one male sex partner in the past twelve months(0.77) obtained from CDC HIV Surveillance Special Report, 2014

[g]MSM with negative HIV status in the US who reported condomless anal sex with a main or casual partner during the past twelve months (0.57) obtained from CDC HIV Surveillance Special Report, 2014

[h]HIV negative MSM in US diagnosed with a sexually transmitted infection in the past twelve months (0.088) obtained from CDC HIV Surveillance Special Report, 2014

[i]HIV negative MSM in US who did not know the HIV status of their most recent male partner (0.39 obtained from CDC HIV Surveillance Special Report, 2014

[j]Percent of US MSM with indications for PrEP from Smith et al., 2015

[k]These are reported cases of HIV and underestimate the actual number of people who are infected

Conclusions

This dissertation sought to summarize population-based methods to estimate the size of the population of MSM, identify gay neighborhoods using the percent of male-male unmarried partners, the density of gay bars, and HIV prevalence data for MSM using LCA, and estimate the size of the MSM population in Florida by ZIP code, rural/urban residence, county, and indications for pre-exposure prophylaxis (PrEP) use. Knowing the size and location of the MSM population in Florida could be beneficial to reducing the acquisition of HIV among this at-risk population.

Twenty-eight studies met the inclusion criteria for the systematic review. Seven studies used surveillance data, eighteen studies used survey data, and six studies used census data. Studies using surveillance data obtained the highest estimates of the MSM population size while those using survey data obtained the lowest estimates. Sixteen studies were conducted in the United States, five in European countries, two in Canada, three in Australia, one in Israel, and one in Kenya. Men who have sex with men accounted for 0.03% to 6.4% of men among all studies and ranged from 3.8% to 6.4% in the US, 7,000 to 39,100 in Canada, 0.03% to 6.5% in European countries, and 127,947 to 182,624 in Australia. Studies also estimated the MSM population size by dimensions of sexual orientation. In studies examining these dimensions, fewer people identified as MSM than reported experience with or attraction to other men.

In the second study, a two-class model was selected based on fit statistics for LCA. Data at the ZIP code level was drawn from the American Community Survey, website lists of gay bars and neighborhoods, and the Florida Department of Health HIV

surveillance system. About 9% of the ZIP code data was in class two, which was designated as gay neighborhoods. Cohen's kappa coefficient was used to examine agreement between the classification of ZIP codes from LCA and websites. Fair agreement was found (0.2501).

In the third study, three methods were used to estimate the MSM population in Florida. Two methods used the number of male-male unmarried partner households while the other used the expected proportion of MSM among men multiplied by number of men aged 15 and older. The estimates from these methods were averaged, and the number of MSM living with HIV infection in each ZIP code was removed. National risk estimates from NHBS were applied to the number of presumed HIV-negative MSM to obtain PrEP eligible MSM. The average MSM estimate in ZIP codes ranged from 1–2,184 men (1.5–22.9%). Indications for PrEP were highest for MSM with more than one sex partner in the past year and lowest when the estimate was multiplied by 24.7%.

Estimating populations at risk for HIV infection is a priority for international organizations, such as the World Health Organization (Wesson et al., 2017). Knowing the size and location of the MSM population is important to interpret HIV and STI surveillance data, and to appropriately allocate resources and target prevention programs such as PrEP. Having these estimates could help track progress towards goals of the National HIV/AIDS Strategy and the Ending the Epidemic Plan to reduce new HIV infections and expand access to prevention services. Historically gay neighborhoods, such as Wilton Manors or Miami Beach in Florida or areas with high numbers of PrEP eligible MSM, could be a place to direct these prevention resources and programs.

The data used in this dissertation is subject to limitations. Survey data can have small sample sizes, which may result in a broad range when the behavior is rare (Archibald et al., 2001). The questions used to identify MSM or recall periods may not be consistent across surveys, and people may be reluctant to self-report sensitive behaviors due to stigma (Archibald et al., 2001; Purcell et al., 2012). Error in classification of male-male unmarried partner households has been reported, which could affect the accuracy of census estimates (O'Connell & Feliz, 2011). No research has come up with established and validated cutoffs for classifying neighborhoods as gay versus not gay using census data (Kelly et al., 2012; Carpiano et al., 2011; Frye et al., 2010). Trying to identify gay neighborhoods through websites is problematic. Some websites listed entire metropolitan areas as gay. Metropolitan areas were excluded from the list of gay ZIP codes from websites because it is unlikely that all ZIP codes in a metropolitan area are gay. Therefore, the website list of gay ZIP codes used in this study may not be comprehensive. National estimates were applied to ZIP code data for estimating MSM. These may not be representative of small geographic units and MSM could vary by location (Purcell et al., 2012; Grey et al., 2016). At present there is no agreed upon method to estimate the size of the MSM population or PrEP eligible MSM. Given the limitations of each source of data, census, surveillance, and survey, it would be prudent to consider multiple sources to provide a possible range of estimates as opposed to rely on one source.

The US Census Bureau is planning to ask questions about same-sex spouses in addition to unmarried partners in the 2020 Census and the American Community Survey (US Census Bureau, 2018). Future studies could use these questions to get a more

complete picture of the size and location of the MSM population. Future studies could also look at awareness and uptake of PrEP in Florida using the estimate of PrEP eligible MSM.

The study findings highlight the importance of having an estimate of the size and location of the MSM population in Florida for planning HIV/STI prevention efforts. Gay neighborhoods and areas with high numbers of MSM or PrEP eligible MSM could be targeted with information on the importance of PrEP to prevent HIV infection in Florida, a state where 63% of persons who received a new HIV diagnosis were MSM and 54% of those living with an HIV diagnosis were MSM in 2017 (Florida Department of Health, 2019).

In conclusion, there is no widely accepted method to estimate the size of the MSM population, and estimates vary substantially based on the method used. Therefore, it would be prudent to consider a range of estimates in planning HIV prevention efforts.

VITA

DANIEL MAUCK

Born, North Carolina, USA

2003–2007	Bachelor of Science, Biology Coastal Carolina University Conway, South Carolina
2010–2012	Master of Science, Biology University of Nebraska at Kearney Kearney, Nebraska
2014–2015	Master of Public Health Georgia Southern University, Armstrong Campus Savannah, Georgia
2015–2017	Doctoral Student Florida International University Miami, Florida
2015–2018	Graduate Assistant Florida International University Miami, Florida
2018–2019	Dissertation Year Fellow University Graduate School Florida International University Miami, Florida
2017–2019	Doctoral Candidate Florida International University Miami, Florida

PUBLICATIONS

Myers KO, Ibrahimou B, Adegoke KK, Mauck DE, Salihu, HM. The Effect of Maternal Vitamin C Intake on Fetal Telomere Length. *J Matern Fetal Neonat Med*. 2019;[Epub ahead of print].

Trepka MJ, Sheehan DM, Fennie KP, Mauck DE, Lieb S, Maddox LM, Niyonsenga T. Racial/ethnic disparities in failure to initiate HIV care: Role of HIV testing site, individual factors, and neighborhood factors, Florida, 2014–2015. *J Health Care Poor Underserved*. 2018;29(3):1153–1175.

Ward-Peterson M, Fennie K, Mauck D, Shakir M, Cosner C, Bhoite, P, Trepka MJ, Madhivanan, P. Using multilevel models to evaluate the influence of contextual factors on HIV/AIDS, sexually transmitted infections, and risky sexual behavior in sub-Saharan Africa: a systematic review. *Ann Epidemiol*. 2018;28(2):119–134.

Mauck DE, Sheehan DM, Fennie KP, Maddox LM, Trepka MJ. Role of gay neighborhood status and other neighborhood factors in racial/ethnic disparities in retention in care and viral load suppression among men who have sex with men, Florida, 2015. *AIDS Behav*. 2018;22(9):2978–2993.

Sheehan DM, Fennie KP, Mauck DE, Maddox LM, Lieb S, Trepka MJ. Retention in HIV Care and Viral Suppression: Individual- and Neighborhood-Level Predictors of Racial/Ethnic Differences, Florida, 2015. *AIDS Patient Care STDs*. 2017;31(4):167–175.

Cyrus E, Dawson C, Fennie KP, Sheehan DM, Mauck DE, Sanchez M, Maddox LM, Trepka MJ. Disparity in Retention in Care and Viral Suppression for Black Caribbean-Born Immigrants Living with HIV in Florida. *Int J Environ Res Public Health*. 2017;14(3):pii: E285.

Sheehan DM, Mauck DE, Fennie KP, Cyrus EA, Maddox LM, Lieb S, Trepka MJ. Black-white and country of birth disparities in retention in HIV care and viral suppression among Latinos with HIV in Florida, 2015. *Int J Environ Res Public Health*. 2017;14(2):pii: E120.