



Published in final edited form as:

Sex Health. 2019 November ; 16(6): 527–538. doi:10.1071/SH18172.

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

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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, 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

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Author Disclosure Statement

The authors declare no conflicts of interest.

Background

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) (1). 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) (2, 3).

Several methods have been developed to estimate the size of hard-to-reach populations (2). 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 (2, 4). It is difficult to directly estimate the size of this population 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 (4). Other methods have been used to estimate population sizes and include capture-recapture, network scale-up, wisdom of the crowds, multiplier, and Delphi (2, 5). 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 (2, 5).

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 (3, 4) 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) (6). 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) (7, 8). 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 (4). 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 (2, 4). 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 (9, 10). Covidence was used to manage screening of studies (10). 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 (4). The following formula was used in Raymond et al. (2018) and can be used as a guide: $(\text{HIV cases in the registry} * \% \text{ undiagnosed HIV infection}) / \% \text{ HIV prevalence}$ (34).

Numerators in studies included the number of MSM tested for HIV in Canada from provincial serodiagnostic databases (11), HIV prevalence among MSM in Miami from the Florida Department of Health (12, 13), the average HIV seroprevalence rate for young Black MSM (YBMSM) from the Chicago Department of Public Health (14), 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 (15), and HIV/AIDS cases and an estimate of undiagnosed HIV infection from case surveillance data in San Francisco (16, 34).

Denominators included the proportion of MSM that reported HIV testing in Canada from studies (11), estimated HIV seroprevalence among MSM from the U.S. Urban Men's Health Study (12), HIV seropositivity rates among MSM from the U.S. National HIV Behavioral Surveillance system (NHBS) (13), population-based seroprevalence rate among YBMSM in Chicago from NHBS and Social Risk and Network Assessment (14), the sample size from a national survey and the number of HIV cases diagnosed among MSM in 2009 (15), and HIV prevalence from studies and case counts (16), and NHBS (34) (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 (4). Many surveys rely on questions related to sex with a man during the previous 12 months, five years, or ever (4). 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 (14). Surveys measured the following behaviors: proportion of men reporting MSM behavior in the past year from the Canada Health Monitor (11), the percent of the adult male population that had ever had sex with a man from National Health and Nutrition Examination Survey (NHANES) (17), proportions of MSM from NHBS (18), percent of men who reported ever having sex with another man from National Survey of Family Growth (NSFG) (14), percentage of same-sex attraction, experience, or identity from Australian Study of Health and Relationships (ASHR) (19), any same sex attraction, lifetime history of same-sex sexual behavior, or self-identification as gay or bisexual (21), prevalence of MSM occurrence (22), recent male-male sex from NHANES (23), current homosexual or bisexual identity from ASHR (24), same-sex behavior in the past 5 years (3), proportion of homosexual experience from postal surveys (28), same sex attraction, experience, or identity from National Survey of Sexual Attitudes and Lifestyles III (NATSAL III) (36), proportion of men who identified as gay from ASHR 2 (37), and the proportion who had at least one male sex partner in the previous year from ASHR 2 (37) (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 (4, 11). 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 (29). Numerators included the proportion of men age 45 and older that had never been married from a census (11), percent of male-male unmarried partner households in a county from census data (29, 4), and same sex male partners in a state from census data (30, 31 32) and county (32). Denominators included the census population of adult men age 15 and over from a census (11) and the number of men in a county or state from ACS or census data (4, 29–32) (Table 4).

Sampling/recruitment

Samples in surveillance-based studies included all individuals who came for HIV testing (11), persons diagnosed with HIV and reported to Florida Department of Health (12, 13), YBMSM living with HIV in Chicago (14), national surveillance data on newly diagnosed HIV infections among MSM (15), and HIV case registry for San Francisco (16, 34). Samples in survey-based studies included the population reporting MSM behavior in the past year or lifetime (11), the civilian general household population (17, 23, 35), MSM in San Francisco through standardized behavioral surveys (18), a nationally representative multi-stage area probability sample survey from US households (14), a national representative population-based survey (19, 24, 37), behavioral surveys among MSM (20), a random sample of Jewish males (21), probability and stratified cluster samples of US households (3), a national population-based cross-sectional survey (25), a probability sample survey (26, 36), a stratified random sample of youth (27), and simple random samples in Norway (28). Census-based studies used data from the US Census Bureau (4, 29–32) or a national census (11).

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 (17, 23, 3, 35, 29, 31, 4). Harris et al. (2013) estimated that 4.7% of men were MSM and or about 4.5 million MSM (17). 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 (23). Purcell et al. (2012) estimated that 3.9% of men engaged in same-sex behavior in the past five years (3). Esie et al. (2018) estimated that the prevalence of having at least one lifetime same-sex partner was 5.5% (35). In de Voux et al. (2015), it was reported that 3.8% of men or about 3.9 million men were MSM (29). Lieb et al. (2011) estimated that the overall percentage of males in the US who were MSM was 6.4% or 7.1 million (31). Campagna et al. (2015) estimated at 6.4% of men in Texas were MSM (32). In Grey et al. (2016), the authors reported that 3.9% of men or 4.5 million men in the US were MSM (4). 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 (30, 32, 16, 34, 18, 27, 12, 13). Lieb et al. (2009) reported that 6% of men or 2.4 million men in the South were MSM (30). Campagna et al. (2015) estimated at 6.4% of men in Texas were MSM (32). 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 (16). Raymond et al. (2018) used HIV case registry data and NHBS survey data to estimate that 63,242 men in San Francisco were MSM (34). Hughes et al. (2017) used data from the NHBS and reported that there were 58,605 MSM in 2014 (18). 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) (27). 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 (12, 13). 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 (12). 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 (13).

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 (11). The number in Vancouver varied from 7,000 using survey data to 26,500 using census-based data (11). In Montreal, the number of MSM varied from 18,500 using survey data to 37,000 using census-based data (11). 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 (25).

Three studies estimated the size of the MSM population in Australia (19, 24, 37). 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 (19). 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 (19). 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 (24). Zablotska et al. (2018) estimated that there were 127,947 sexually active 16–69 year-old gay men (37).

Five studies were conducted in Europe (15, 20, 26, 28, 36). 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 (15). Marcus et al. (2009) estimated that 2.9% of men in Germany were MSM (20). Ruf et al. (2011) reported that 5.5% of men or 98,330 MSM were living in inner London in 2008 (26). 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 (28). 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 (36). 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 (19). 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 (19). Prestage et al. (2008) estimated that 2.5% of men overall in Australia identified as homosexual or bisexual (24). Zablotska et al. (2018) estimated that there were 127,947 of sexually active 16–69 year-old gay men in Australia (37). Shields et al. (2013) reported that 3.8% of middle school students identified as lesbian,

gay, or bisexual (27) in San Francisco. Mor et al. (2016) reported that 11.9% of men reported lifetime male sexual encounters while 4.5% identified as gay in Israel (21). 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 (36).

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 (29, 31). Studies in 38 countries in Europe estimated that 0.03–6.5% of men are MSM (15). 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 (11, 25). Studies in Australia found that 127,947–182,624 men identified as homosexual or bisexual (37, 24). 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 (36). 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 (3, 5). The proportion of men that openly identify as MSM depends on social acceptance, and differs between countries and regions (20, 31). 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 (22). 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 (32). Underreporting of same-sex behavior or identity due to stigma could result in an underestimate of the size of the MSM population (3).

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 (2, 5). 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 (16). People being tested for HIV may be engaging in higher risk activities (16). Survey-based methods may use a national sample and can estimate MSM in the general population (3). 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 (19, 36). Behavior would be the most important dimension as it can lead to sexual transmission of HIV and STIs (4). 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 (30). It can be used to estimate MSM by the various geographic units that are available in census data (e.g., state, county) (30, 35, 4). 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 (34).

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) (16). People attending an STD clinic may be engaging in high-risk activities and could lead to an overestimate (16). Survey-based methods may have small sample sizes, which is a problem if the behavior is rare (11). This can result in a broad range for the estimates (11). The questions used to identify MSM or recall periods may not be the same across surveys (11, 3). People may be reluctant to self-report sensitive behaviors due to stigma (11, 14, 3). The focus of the survey could also affect the estimate (e.g., people at risk for HIV may not represent all MSM) (17). The delivery method of the survey may also affect the estimate (interviewer or self-administered) (25). Survey-based methods often use national surveys and may not allow for generalization to or be representative of small geographic units (3). Additionally, the MSM population may vary by location (4). 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 (33). Stigma could lead to males inaccurately reporting their relationship and an underestimate of the data used in these studies (32). National estimates were used to derive state estimates used in the calculations, and this could be inadequate due to uneven dispersion of MSM (4, 30).

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.

Conclusion

Estimating populations at risk for HIV infection is a priority for international organizations, such as the World Health Organization (2). 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 MSM 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.

Acknowledgment

Financial support was received from the Dissertation Year Fellowship from the University Graduate School at Florida International University. Research reported in this publication was partially supported by the National Institute on Minority Health and Health Disparities of the National Institutes of Health under Award Number K01MD013770. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

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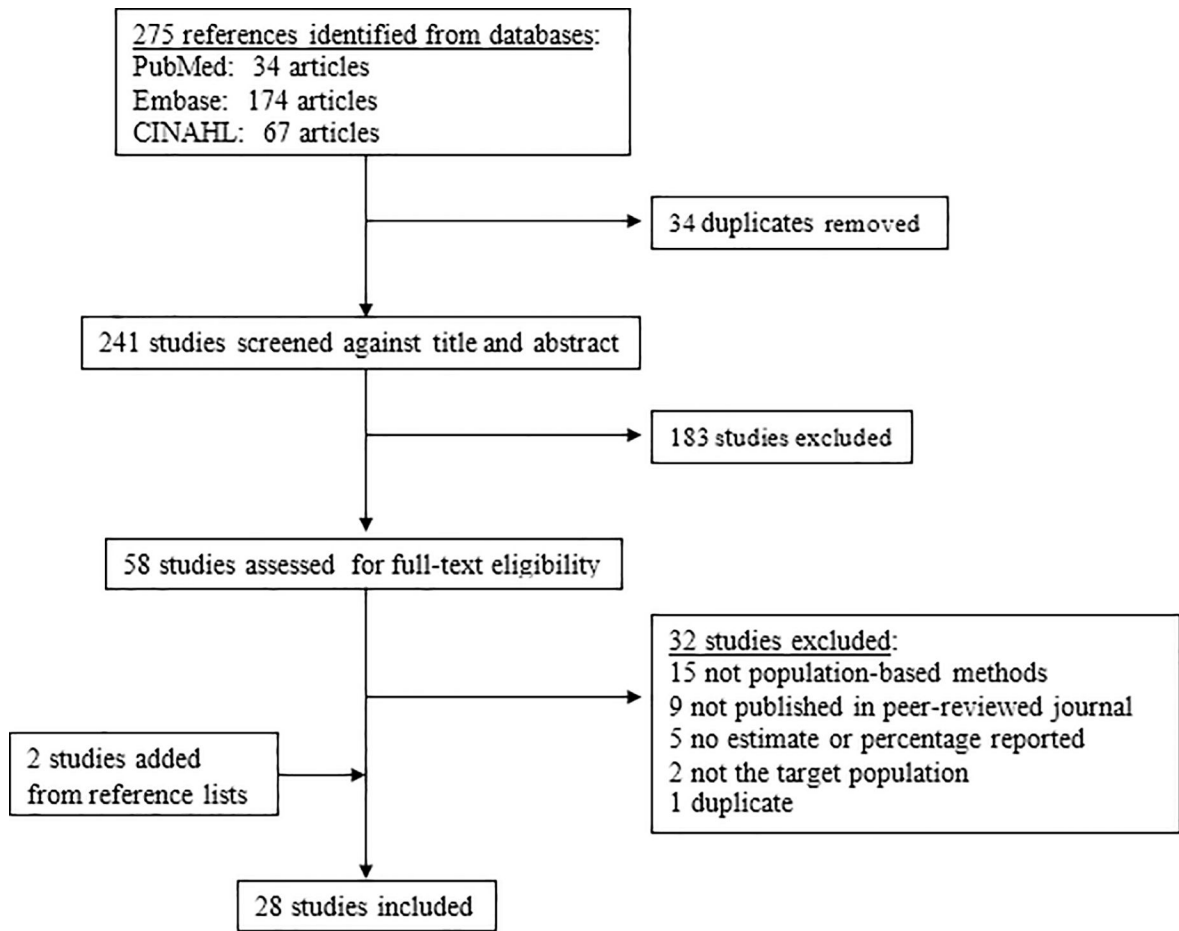


Figure 1. Flowchart of screening process of studies using population-based methods for estimating the number of men who have sex with men

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")

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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 (11)	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 epi 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 (12)	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 (13)	United States/ Florida/ Miami-Dade County MSA	HIV prevalence in Miami MSA/HIV seropositivity rates from NHBS ^d	Florida Department of Health, NHBS	7.5%	63,020 in Miami MSA for 2003 to 2005	HIV-infected MSM living and residing in the Miami MSA	All men aged 18 years who had male-male sex contact since 1978
Livak et al., 2013 (14)	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 (15)	Europe	$N_{pop} = HIV_{pop} * N_{svy} * S_{SD} / HIV_{svy}$ HIV _{pop} , the number of HIV cases diagnosed among MSM reported to the countries surveillance system in 2009; N _{svy} , the sample size in a national survey; HIV _{svy} , the number of those survey participants diagnosed with HIV in 2009; N _{tot} , the number of men in the country; M, the proportion who have sex with men $SSD = HIV_{svy} * M * N_{tot} / N_{svy} * HIV_{pop}$	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 (16)	United States/ California/San Francisco	$(HIV/AIDS)^i$ Cases * undiagnosed infection/HIV prevalence	Case surveillance data, HIV prevalence estimates, United States 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 (34)	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	Not reported	63,242 MSM	HIV case registry for the city of San Francisco	Not listed

Author, year	Country/ State/City	Calculation	Source of data, years from case registry in 2016	Percent of MSM	Number of MSM	Sampling method	Characterization of study population

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 (11)	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 (3)	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 (14)	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 from US households	Men who have had male–male sexual contact
Harris et al., 2013 (17)	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 (18)	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 (19)	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% 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	Selected inner east: identity-9,269, experience-12,979, attraction-13,508. Selected inner west: identity-3,464, experience-4,797, attraction-5,573	national representative population-based survey, participants were selected at random from the general population to participate in a telephone survey	Male participants who reported lifetime experience of sex with men, feelings of same-sex attraction during their lifetime, and/or a current homosexual or bisexual identity
Marcus et al., 2009 (20)	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 offline too for GMA)	Male participants in the age group 20–50 years who reported sexual contacts with men in the previous 12 months

Mor et al., 2016 (21)	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 (22)	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	Had oral or anal sex with man
Oster et al., 2015 (23)	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 male-male sex in the past 12 months	5,933,000 ever; 3,156,000 in past 12 months	Nationally representative sample of the civilian, noninstitutionalized population	Among men, having had oral or anal sex with another man during the past 12 months/ever
Prestage et al., 2008 (24)	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 (25)	Canada/Vancouver	Calculated median estimate for Vancouver urban core from 2 survey cycles	CCHS ¹ 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 (26)	United Kingdom/London	Estimated inner London MSM proportion from NATSAL ^k * 2008 inner London male population	British NATSAL 2000 and Greater London Authority population estimates 2008	5.5%	98,330 MSM aged 16–44 were living in Greater London in 2008	Probability sample survey of men and women using computer-assisted interviews	Partners of the same gender with whom the respondent had any form of genital contact
Shields et al., 2013 (27)	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 (28)	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 past 3 years	188 lifetime; 57 past 3 years	Simple random samples drawn from the Central Population Registry, postal questionnaires sent	Had any form of sexual interaction with a person of the same gender as yourself ever/in past 3 years
Estie et al., 2018 (35)	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 (36)	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	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 (37)	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:

- ^aMSM-Men who have sex with men
- ^bCHM-Canada Health Monitor
- ^cNSFG-National Survey of Family Growth
- ^dNHANES-National Health and Nutrition Examination Survey
- ^eNHBS-National HIV Behavioral Surveillance
- ^fHIV-Human immunodeficiency virus
- ^gASHR-Australian Study of Health and Relationships
- ^hKaBaSTI-Knowledge, Attitudes and Behaviour as to Sexually Transmitted Infections
- ⁱGMA-Gay Men and AIDS survey
- ^jCCHS-Canadian Community Health Survey
- ^kNATSAL-National Survey of Sexual Attitudes and Lifestyles
- ^l>YRBS-Youth Risk Behavior Survey
- ^mLBG-Lesbian, gay, or bisexual
- ⁿONS-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 (11)	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 (29)	United States/44 states	Percent MSM ^d = 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	American Community Survey summary data	Households with a male head and a male partner
Lieb et al., 2009 (30)	United States/17 southern states	Model A: % MSM state _i = (rural male population state _i * 0.01) + (suburban male population state _i * 0.04) + (urban male population state _i * 0.09) Model B: 1. MSM index = state _i (#SSMP ^e state _i / #SSMP US / (#households state _i / #households US)) 2. Percent MSM state _i = (MSM index state _i * % MSM Model A state _i) 3. Average % MSM state _i = (% MSM model A state _i + % MSM model B state _i) / 2. 4. Number of MSM state _i = average % MSM state _i * adult male population state _i . Model C: Race _i / MS _i estimate = average % MSM state _i * race _i adult male population state _i * % MSM ratio for race _i . Model C final estimate = White MSM estimate + Black MSM estimate + Hispanic MSM estimate + Other race MSM estimate	2000 Census, NSFG ^d , ACS	6.0% in the south	2.4 million in the south 1,656,500 (69%) whites, 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	US Census Bureau; multi-stage area probability sample (NSFG)	Adult males who ever had sex with another male
Lieb et al., 2011 (31)	United States	Model A: % MSM state _i = (rural male population state _i * 0.01) + (suburban male population state _i * 0.04) + (urban male population state _i * 0.09) Model B: 1. MSM index = state _i (#SSMP state _i / #SSMP US / (#households state _i / #households US)) 2. Percent MSM state _i = (MSM index state _i * % MSM Model A state _i) 3. Average % MSM state _i = (% MSM model A state _i + % MSM model B state _i) / 2. 4. Number of MSM state _i = average % MSM state _i * adult male population state _i . Model C: Race _i / MS _i estimate = average % MSM state _i * race _i adult male population state _i * % MSM ratio for race _i . Model C final estimate = White MSM	2000 Census, NSFG, ACS	Overall US percentage of males who were MSM was 6.4%, varied from 3.3% in South Dakota to 13.2% in the District of Columbia	7.1 million MSM residing in the US in 2007; 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 Hawaiian/other Pacific Islander, and 0.6% (41,000) were of multiple/unknown race/ethnicity	US Census Bureau; multi-stage area probability sample (NSFG)	Adult males aged 18 years with a lifetime history of any male-male sexual contact

Author, year	Country/State/City	Calculation	Source of data, years	Percent of MSM	Number of MSM	Sampling method	Characterization of study population
Campagna et al., 2015 (32)	United States/ Texas/ counties	estimate + Black MSM estimate + Hispanic MSM estimate + Other race MSM estimate Model A: % MSM county=(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 countyi + %MSM model B countyi)/2. 4. Number of MSMcountyi= average% MSMcountyi * adult male population countyi. Model C: Racei/MSMestimate= 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	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
Grey et al., 2016 (4)	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. MSM countyi urbanicity j= (%MSM countyi urbanicityj * Adult males countyi urbanicityj) 4. (impute) SSM households countyi urbanicityj= SSM households countyi urbanicityj+(total households countyi urbanicityj * %SSM households 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

Abbreviations:

^aMSM-Men who have sex with men

^bACS-American Community Survey

^cNCHS-National Center for Health Statistics

^dNSFG-National Survey of Family Growth

^eSSMP-Same sex male partner

^fSSM-Same sex male