

Estimating the Size of the MSM Population in Metro Vancouver, Canada, Using Multiple Methods and Diverse Data Sources

Ashleigh J. Rich · Nathan J. Lachowsky · Paul Sereda · Zishan Cui · Jason Wong · Stanley Wong · Jody Jollimore · Henry Fisher Raymond · Travis Salway Hottes · Eric A. Roth · Robert S. Hogg · David M. Moore

Published online: 19 June 2017
© The New York Academy of Medicine 2017

Abstract Men who have sex with men (MSM) are disproportionately affected by HIV globally, regionally in Canada, and locally in Vancouver. Lack of reliable population size estimates of MSM impedes effective implementation of health care services and limits our understanding of the HIV epidemic. We estimated the population size of MSM residing in Metro Vancouver drawing on four data sources: the Canadian Community

Health Survey (CCHS), a cross-sectional bio-behavioural MSM survey, HIV testing services data from sexually transmitted infection (STI) clinics serving MSM, and online social networking site Facebook. Estimates were calculated using (1) direct estimates from the CCHS, (2) “Wisdom of the Crowds” (WOTC), and (3) the multiplier method using data from a bio-behavioural MSM survey, clinic-based HIV testing, and

Key Messages • Men who have sex with men (MSM) are disproportionately affected by HIV globally, nationally in Canada, and locally in Vancouver, British Columbia.

- Lack of reliable population size estimates of MSM impedes effective implementation of health care services and limits our understanding of the HIV epidemic.
- Using diverse data sources and methods, our median estimate of the MSM population in Metro Vancouver was 27,183.
- The corresponding 2.9% proportion of MSM in the male census population of Metro Vancouver was similar to estimates from other jurisdictions.
- These findings will help support better public health planning and understanding of the HIV epidemic among MSM.

A. J. Rich (✉) · N. J. Lachowsky · P. Sereda · Z. Cui · R. S. Hogg · D. M. Moore
Epidemiology and Population Health Program, British Columbia Centre for Excellence in HIV/AIDS, 505-1200 Burrard Street, Vancouver, BC V6Z 2C7, Canada
e-mail: arich@cfenet.ubc.ca
A. J. Rich · D. M. Moore
Faculty of Medicine, University of British Columbia, Vancouver, BC, Canada

N. J. Lachowsky
School of Public Health and Social Policy, Faculty of Human and Social Development, University of Victoria, Victoria, BC, Canada

J. Wong · S. Wong · T. S. Hottes · D. M. Moore
British Columbia Centre for Disease Control, Vancouver, BC, Canada

J. Jollimore
Health Initiative for Men (HIM), Vancouver, BC, Canada

H. F. Raymond
University of California—San Francisco, San Francisco, CA, USA

T. S. Hottes
University of Toronto, Toronto, ON, Canada

online social media network site Facebook. Data sources requiring greater public disclosure of sexual orientation resulted in our mid-range population estimates (Facebook 23,760, CCHS 30,605). The WOTC method produced the lowest estimate, 10,000. The multiplier method using STI clinic HIV testing data produced the largest estimate, 41,777. The median of all estimates was 27,183, representing 2.9% of the Metro Vancouver census male adult population, with an interquartile range of 1.1–4.5%. Using multiple data sources, our estimates of the MSM population in Metro Vancouver are similar to population prevalence estimates based on population data from other industrialized nations. These findings will support understanding of the HIV burden among MSM and corresponding public health and health services planning for this key population.

Keywords MSM · Population size · HIV · Canada · Respondent-driven sampling

Introduction

Men who have sex with men (MSM) are disproportionately affected by HIV globally [1] and in North America [2]. In British Columbia (BC), Canada, MSM make up the greatest proportion of prevalent HIV infections, 45% in 2011, and a majority of all new HIV diagnoses, 58% in 2014 [3]. The number of prevalent HIV infections continues to rise in BC secondary to improved survival of persons infected as well as new infections. Meanwhile, the number of new HIV diagnoses among MSM has remained largely unchanged since 2005, while the absolute number of new diagnoses has declined overall in BC [3]. While rates of new diagnoses among men in BC are likely declining due to population growth, it is unknown whether this trend holds among MSM, due to lack of reliable estimates for the MSM population size. Provincially, the disease burden is concentrated in Metro

Vancouver where over two-thirds of new infections in MSM were diagnosed in 2014 [3]. Geographic clustering of sexual minority populations to urban centres is a recognized phenomenon [4]. In 2008, it was estimated that 56% of gay men and 47% of bisexual men in Canada live in the large metropolitan areas of Toronto, Montreal, and Vancouver [5].

Lack of reliable MSM population size estimates impedes effective health service planning and limits understanding of the HIV epidemic. Because sexual orientation has typically not been collected by census data in Canada and globally, MSM have remained a “hidden population” for which there is no pre-existing sampling frame from which to draw representative samples [6–8]. Inconsistent sexual orientation measurement definitions (e.g. behaviour vs. identity-based) [9], challenges to collecting MSM data through surveillance or population studies [10], and social stigma affecting disclosure and participation [11] may all contribute to this difficulty. Together these factors have impeded an accurate depiction of the HIV epidemic in this high-risk population.

Measuring the size of key populations for HIV and other sexually transmitted infection (STI) prevention activities has proven challenging in most jurisdictions. Estimates of MSM populations, particularly those in urban centres, have been predominately based on population surveys [12–14], capture-recapture estimates [15, 16], and indirect sampling through serodiagnostic databases [17, 18]. Importantly, few studies have integrated population-specific bio-behavioural data with multiple population size estimation methods [16, 19]. More diverse methodology and use of multiple data sources has the potential for a more accurate understanding of the HIV epidemic among key populations, such as MSM [20–22].

As HIV continues to be a significant public health concern among MSM in Metro Vancouver, we developed population size estimates for MSM using diverse methods and local data sources.

Methods

Data Sources

National Population-Based Survey

The Canadian Community Health Survey (CCHS) is an ongoing national population-based cross-sectional

E. A. Roth
Department of Anthropology, Faculty of Social Sciences,
University of Victoria, Victoria, BC, Canada

E. A. Roth
Centre for Addictions Research BC, Victoria, BC, Canada

R. S. Hogg
Faculty of Health Sciences, Simon Fraser University, Burnaby,
BC, Canada

survey of the health status, utilization, and determinants of the Canadian population over 12 years of age living in private homes with telephone access [23]. Conducted by Statistics Canada, interviewer-administered telephone surveys are completed annually from a random sample of 65,000 respondents over the 110 health regions in Canada and are designed to provide reliable estimates at the health region level, representing approximately 98% of the national population. The CCHS provided 2011–2012 and 2013–2014 weighted estimates of the number of self-identified homosexual, gay, or bisexual men aged 18–59 years old based on the question, “Do you consider yourself to be: 1) heterosexual (sexual relations with people of the opposite sex); 2) homosexual, that is lesbian or gay (sexual relations with people of your own sex); 3) bisexual (sexual relations with people of both sexes)?”

Bio-behavioural MSM Survey

The Momentum Health Study provided data from a Vancouver-based cross-sectional MSM survey, collected between February 2012 and February 2014 [6]. The study methods have been described further elsewhere [24]. Briefly, participants were recruited via respondent-driven sampling (RDS), were aged 16 or older, identified as men, reported sex with other men in the 6 months prior to baseline, and resided in Metro Vancouver. Momentum provided data for estimates of the MSM population size, in response to the question, “To the best of your knowledge, how many men who have sex with men, whether they identify as gay or not, do you think live in the Greater Vancouver region?”; the proportion of participants reporting a Facebook profile; and the proportion of participants reporting HIV testing at each of three public sexual health clinics popular among MSM in the 2 years prior to enrollment. Population parameter estimates for variables of interest were generated using weights based on recruiter-recruit homophily and participant social network size, using RDSAT software [25].

Health Services Access Data

Aggregated data on HIV testing volumes for MSM clients came from the British Columbia Centre for Disease Control (BCCDC), specifically from three BCCDC-supported sexual health clinics serving MSM. The Bute Street Clinic serves the LGBT community,

including MSM; Health Initiative for Men (HIM) clinic on Davie Street is located in the Vancouver gay village and predominately serves MSM; and the BCCDC provincial sexual health clinic serves the general population though counts MSM as a large proportion of their patient population. Data were provided for the period September 2011 to February 2014 to overlap with the Momentum study data period.

Online Social Networking Site

Publicly available data from the ad-buying interface of popular online social networking site Facebook provided the number of men with user profiles as of November 2014 who reported being aged 16 to 65 years or older, living within 25 miles of Vancouver, and being “interested in men” or “interested in men and women” on their public profiles.

Methods of Estimation

Direct Weighted Population Estimates

The CCHS provided direct population estimates from the 2011–2012 to 2013–2014 survey cycles for the Vancouver Urban Core (defined as a large urban area around a census metropolitan area with a population of 50,000 or more) [26], weighted to account for survey design [27]. For the CCHS, we calculated the median estimate of the two survey cycles, to provide a more robust estimate.

Wisdom of the Crowds

Direct estimates of the Metro Vancouver MSM population size were based on the “Wisdom of the Crowds” (WOTC) method, using responses to the Momentum size of the MSM population question. The WOTC method is based on the perceived size of the local MSM population by MSM survey respondents and has been used to produce plausible MSM population estimates in other settings [19, 28, 29]. It is based on the overall assumption that the population members’ estimates of the number of members in the population, from survey responses, approximate the actual number of members in the population [30] and the specific assumptions that (1) population members in a large sample are likely to have unique information about the population and (2) individual responses to a question asked to all

respondents in the sample are not influenced by other responses, and when responses are aggregated, outliers are likely to negate each other [19]. For the WOTC, we calculated the median response and the interquartile range.

Calculated Population Estimates

Using indirect or multiplier methods [18, 31], we calculated population estimates by the formula $N = n/p$ where N is the population size estimate, n is the number of MSM who are members of a particular group at one time (i.e. HIV testers at a specific BCCDC clinic), and p is the proportion of MSM reporting corresponding group membership during the same period (i.e. MSM reporting testing at the specific BCCDC clinic, in the bio-behavioural survey). We used the multiplier method to produce two sets of calculated population estimates, based on HIV testing services and Facebook use, respectively. We calculated 95% confidence intervals for both estimates, based on the RDS-weighted data. We adjusted the health services-based estimates by the average number of tests in the past 2 years reported by Momentum respondents at one or more of the specific sexual health clinics, which represented the 2-year period of study data collected. The denominator for p used all bio-behavioural study participants. We also calculated the median of HIV testing-based estimates, to provide a more robust estimate.

Results

Population Estimates

Direct Population Estimates

All population estimates are presented in Table 1. For the CCHS data, the median-calculated Vancouver Urban Core estimate was 30,605. For the WOTC method, the median was 10,000, with an interquartile range from 200 to 75,000.

Calculated Population Estimates

From the 719 participants in the Momentum Study sample, 591 participants reported having a current Facebook profile resulting in an RDS-adjusted population proportion of 76.6%. Public data from Facebook

gave a total number of 18,200 eligible profiles from the Metro Vancouver area that indicated both personal gender identity as a man and preferred gender of partners as men or men and women. This produced a total population estimate of 23,760, with an interquartile range of 21,904 to 25,617.

Regarding testing for HIV at local STI clinics in the past 2 years, the following are the RDS-adjusted population proportions: 9.7% reported testing at HIM Clinic-Davie Street, 8.3% tested at the Bute Street Clinic, and 4.1% tested at the BCCDC provincial sexual health clinic. We adjusted estimates for each clinic by the average number of HIV tests reported in the past 2 years at any clinic (1.48) and by the proportion of MSM who had tested at each site, to minimize the impact of duplicate clinic counts. Adjusted estimates ranged from 29,091 (BCCDC) to 63,752 (Bute Street Clinic). The median of the three estimates was 41,777, with an interquartile range of 23,537–60,018.

Discussion

This study provides four primary estimates of the Metro Vancouver MSM population, based on triangulation of four data sources using direct population-based estimates, the WOTC method, and the multiplier method. Taking the median of the four primary estimates shown in Table 1, we estimate there are approximately 27,183 MSM in Metro Vancouver and as many as 41,777. The use of multiple methods and data sources, particularly integration of local RDS-recruited bio-behavioural MSM survey data for several estimates, strengthens our results.

According to 2011 census data, there are 933,425 men 16 years of age and older in the Metropolitan Vancouver area [32]. Using our median population size estimate, MSM comprise approximately 2.9% of the regional adult male population, with an interquartile range between 1.8 and 3.9%. Though lower, our percentage estimate overlaps with a United States (US)-based meta-analysis of population-based surveys conducted by the Centres for Disease Control (CDC). The meta-analysis of surveys with a “past 5-year” sexual behaviour recall period estimated that MSM comprise 3.9% (95% CI = 3.5%, 4.4%) of the US general male population age 13 and older, for 2008 [13].

All data sources required disclosure of sexual identity, attraction, or behaviour and as such may be vulnerable to reporting bias [33]. This limitation may be more

Table 1 Metro Vancouver MSM population estimates, with data sources, methods, and calculations

Method	Calculation	Estimate/ median	95% CI/ acceptability bounds/IQR	% of adult males in Metro Vancouver
WOTC		10,000	200–75,000	1.1
General population survey				
Vancouver Urban Core 2011–2012		31,300		
Vancouver Urban Core 2013–2014		29,910		
Median		30,605		3.3
Multipliers				
Facebook	18,200 profiles/0.766 Momentum respondents reporting a Facebook profile	23,760	21,904–25,617	2.5
HIV testing	Test count/avg # tests per MSM	MSM tested/% MSM who had test at X site = total # MSM tests		
Bute Clinic	7252/1.48 = 4909	4909/0.077	63,752	31,250–96,257
HIM Davie	6110/1.48 = 4136	4136/0.099	41,777	23,537–60,018
BCCDC	1891/1.48 = 1280	1280/0.044	29,091	18 33–56,352
Median			41,777	23,537–60,018
Median of all estimates		27,183	16,880–36,191	2.9 (1.8–3.9)

MSM men who have sex with men, CI confidence interval, IQR interquartile range, WOTC “Wisdom of the Crowds” method, Avg average

pronounced for the online social networking data which required *public* disclosure of gender and sexual attraction in order to be included in our estimate and for the government-sponsored population survey data which collected gender and sexual identity via government-sponsored interviewer-administered questionnaire. Further, these sources did not force response to gender and sexual orientation items; thus, estimates are based only on the proportion of respondents who chose to disclose. For these reasons, population estimates based on the social networking and population survey data may be vulnerable to underreporting bias and thus underestimate the true MSM population size. Such underreporting bias would be consistent with the Facebook data providing a lower estimate than the median of all estimates; however, the CCHS provided an estimate slightly higher than the overall median.

According to a 2014 web-based survey of 8382 Canadian gay and bisexual men, approximately 30% reported they would be unwilling to disclose their sexual identity on a government survey [34]. If this sensitivity was applied to the CCHS data, it would increase the estimate from 30,605 to 39,787. Our behaviour-based estimates, using the WOTC method and HIV testing

data, may also be vulnerable to underreporting or misclassification. Specifically, self-reported same sex behaviour estimates may have a sensitivity of approximately 60–90% [35, 36]. If applied to our HIV testing services-based median estimate, which used clinic data measuring MSM based on voluntary disclosure of behaviour, the sensitivity range provides estimates of 45,955 to 58,488.

The bio-behavioural survey design may have minimized potential bias through the use of RDS for peer-to-peer recruitment and computer-assisted self-interview (CASI), which has been shown to minimize reporting bias [37, 38]. RDS and CASI use may have also served to improve validity of the WOTC estimate, which can be susceptible to social influence [39]. Though the median is used for this estimate, as it is least influenced by outliers, the WOTC method produced our lowest population size estimate, 10,000 (IQR 200–75,000). If there had been a more normal distribution of responses, WOTC may have produced a more plausible estimate. These estimates must be interpreted as a fixed view of this population over the study time period, 2011 to 2014, as one or all of the components of sexuality may change over the life course [40].

Relatedly, data sources employed various sexual orientation dimensions (e.g. attraction, behaviour, identity). Momentum used a sexual behaviour-based measure, as did HIV testing data, likely capturing “men who have sex with men”. This is consistent with providing our largest estimate based on HIV testing data using the multiplier method. Facebook data, based on “interest in” men, or both men and women, used most closely a global attraction measure and potentially captured the widest group. However, this source provided one of our lowest estimates, likely vulnerable to the disclosure-related limitations previously discussed, as well as inability to adjust for MSM who disclose interest in men on their Facebook profiles rather than any Facebook profile in the estimation denominator. The CCHS used sexual identity and likely collected data on gay and bisexual-identifying men, potentially missing those who are sexually active with other men though may identify as other than “homosexual” or “bisexual”. These discrepant measures may be employed for good reason (e.g. data collection efforts related to HIV prevention and transmission would be more interested in behaviour-based measures); however, the use of a particular measure is not always ideal for its purpose. Specifically, as an identity-based measure, the CCHS both captures those gay and bisexual men who are not sexually active (thus, presumably of less interest in terms of HIV transmission) and fails to capture those MSM who do not identify as gay or bisexual (who are of interest in terms of HIV transmission). These inconsistencies suggest the potential benefit of the addition of a behaviour-based sexual orientation measurement to the CCHS, an important resource for health surveillance and population research in Canada, as others have called for [41].

HIV-Positive Subpopulation

An important application of MSM population size estimates is in informing accurate assessment of the scope and burden of HIV among this key population, and corresponding public health and healthcare services planning. We can apply the RDS-weighted serologic testing-based Momentum HIV prevalence, 23.5%, to our overall median population estimate to estimate the number of HIV-positive MSM in Metro Vancouver, resulting in 6388. Though no other estimate of the HIV-positive MSM subpopulation in Metro Vancouver is available for comparison, 2011 provincial estimates

are available from a Public Health Agency of Canada (PHAC) estimation effort using the workbook method [42] with provincial surveillance and census data [3]. According to PHAC, there were approximately 4950 (range 3900–6000 cases) HIV-positive MSM across the province of British Columbia in 2011. While the majority of HIV-positive MSM in BC reside in the Vancouver area [3], it is not plausible that the number of HIV-positive MSM in Metro Vancouver could be greater than the total number of HIV-positive MSM in the province. While the RDS methodology applied in the Momentum Study is designed to identify and allow statistical adjustments in recruiting biases, it is unlikely that it completely eliminates all biases. Momentum may overestimate HIV prevalence among MSM in Vancouver and thus produce an overestimate of the HIV-positive MSM subpopulation, as well.

Limitations

This study has a number of limitations, largely due to biases in individual data sources, potentially exacerbated by the use of the selected methods to estimate this hidden population. Each data source has limitations in the ability to sample all MSM in the true population (e.g. it may not be culturally normative to publicly display gender identity or sexual attraction on online social media sites, which may have led to an underestimate based on these data).

Lack of a gold-standard method for estimating “hidden” populations makes it difficult to assess the accuracy of our estimates and identify which estimate may come the closest to accurately measuring the underlying MSM population. Future efforts to estimate the size of regional and national MSM populations in Canada would be improved by systematic collection of MSM-specific data. Population size estimates would be more robust with standardization of sexual orientation measures used and inclusion of multiple questions measuring the various elements of sexual orientation, across data sources.

To counterbalance potential limitations, we used diverse estimation methods and data sources. The CCHS is an ideal data source for this estimation exercise as the government-sponsored population-based survey is robustly designed to produce reliable regional estimates [43]. Importantly, we relied on RDS-recruited bio-behavioural data for a number of estimates. The use of RDS is designed to produce a more representative sample than

other probability sampling methods [44, 45], though representation of the underlying population cannot be independently confirmed. While RDS allows for measurement and adjustment for recruitment-related biases, it is not possible to adjust for all potential sampling biases. Specific to Momentum, there were challenges to producing long recruitment chains, necessary to penetrate diverse respondent networks and gain independence from the purposively selected initial “seed” recruits.

Despite these limitations, this study provides critical local data on the size of the Metro Vancouver MSM population, as well as making an important contribution to the application of these methods to the estimation of regional key population size. These data have already had [3] and will continue to have practical application for public health planning and policy in the assessment of disease burden and allocation of healthcare resources for this key population for HIV prevention and control.

Acknowledgements This work was supported by the Canadian Institutes for Health Research [107544] and the National Institute for Drug Abuse at the National Institutes for Health [R01DA031055]. We thank the research participants for sharing their important data with the Momentum Health Study. We also thank our community-based partners on the Momentum Health Study Community Advisory Board for their input in this work, including representatives from the Health Initiative for Men, YouthCO HIV & Hep C Society of BC, and Positive Living Society of BC. DMM is supported by a Scholar Award from the Michael Smith Foundation for Health Research.

References

1. Beyrer C, Baral SD, van Griensven F, et al. Global epidemiology of HIV infection in men who have sex with men. *Lancet*. 2012;380(9839):367–77.
2. Hall HI, Geduld J, Boulos D, et al. Epidemiology of HIV in the United States and Canada: current status and ongoing challenges. *JAIDS*. 2009;51(Suppl 1):S13–20.
3. BC Centre for Disease Control. *HIV in British Columbia: annual surveillance report 2014*. <http://www.bccdc.ca/util/about/annreport/default.htm>. Published November 2015. Accessed May 15, 2016.
4. Hughes AJ, Saxton PJ. Geographic micro-clustering of homosexual men: implications for research and social policy. *Soc Policy J N Z*. 2006;28:158–78.
5. Statistics Canada. *Health care use among gay, lesbian and bisexual Canadians*. Vol 19. Health reports. <http://www.statcan.gc.ca/pub/82-003-x/2008001/article/10532-eng.htm>. Published 2008. Accessed 7 June 2016.
6. Heckathorn DD. Respondent-driven sampling: a new approach to the study of hidden populations. *Soc Probl*. 1997;44(2):174–99.
7. Heckathorn DD, Semaan S, Broadhead RS, Hughes JJ. Extensions of respondent-driven sampling: a new approach to the study of injection drug users aged 18–25. *AIDS Behav*. 2002;6(1):55–67.
8. Heckathorn DD. Respondent-driven sampling II: deriving valid population estimates from chain-referral samples of hidden populations. *Soc Probl*. 2002;49(1):11–34.
9. Laumann EO, Gagnon JH, Michael RT, Michaels S. *The Social Organization of Sexuality*. Chicago, IL: University of Chicago Press; 1994.
10. Blair J. A probability sample of gay urban males: the use of two-phase adaptive sampling. *J Sex Res*. 1999;36(1):39–44.
11. Meyer IH, Wilson PA. Sampling lesbian, gay, and bisexual populations. *J Couns Psychol*. 2009;56(1):23.
12. Yang Q, Boulos D, Yan P, et al. Estimates of the number of prevalent and incident human immunodeficiency virus (HIV) infections in Canada, 2008. *Can J Public Health*. 2010;101(6):486–90.
13. 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(1):98–107.
14. Sabin K, Zhao J, Garcia Calleja JM, et al. Availability and quality of size estimations of female sex workers, men who have sex with men, people who inject drugs and transgender women in low- and middle-income countries. *PLoS One*. 2016;11(5):e0155150.
15. Luan R, Zeng G, Zhang D, et al. A study on methods of estimating the population size of men who have sex with men in Southwest China. *Eur J Epidemiol*. 2005;20(7):581–5.
16. Paz-Bailey G, Jacobson JO, Guardado ME, et al. How many men who have sex with men and female sex workers live in El Salvador? Using respondent-driven sampling and capture-recapture to estimate population sizes. *Sex Transm Infect*. 2011;87(4):279–82.
17. 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 synthesising multiple empirical data sources and methods in San Francisco. *Sex Transm Infect*. 2013;89(5):383–7.
18. 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:S41.
19. 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):366–71.
20. Holmberg SD. The estimated prevalence and incidence of HIV in 96 large US metropolitan areas. *Am J Public Health*. 1996;86(5):642–54.
21. Pouget ER, Friedman SR, Cleland CM, et al. Estimates of the population prevalence of injection drug users among hispanic residents of large US metropolitan areas. *J Urban Health*. 2012;89(3):527–64.
22. Tempalski B, Lieb S, Cleland CM, et al. HIV prevalence rates among injection drug users in 96 large US metropolitan areas, 1992–2002. *J Urban Health*. 2009;86(1):132–54.

23. Statistics Canada. *Canadian Community Health Survey (CCHS)—annual component: user guide 2012 and 2011–12 microdata files*. Statistics Canada: Ottawa, ON; 2013.
24. Moore DM, Cui Z, Lachowsky N, et al. HIV community viral load and factors associated with elevated viremia among a community-based sample of men who have sex with men in Vancouver, Canada. *J Acquir Immune Defic Syndr*. 2016;72(1):87–95.
25. *Respondent-Driven Sampling Analysis Tool (RDSAT) Version 7.1*. Ithaca, NY: Cornell University; 2012.
26. Statistics Canada. *Census dictionary*. Ottawa, Canada <http://www12.statcan.gc.ca/census-recensement/2011/ref/dict/geo049a-eng.cfm>. Published 2011. Accessed 15 May 2016.
27. Sarafin C, Simard M, Thomas S. *A review of the weighting strategy for the Canadian Community Health Survey*. In: St John's; 2007. Presented as part of the Statistical Society of Canada conference; 2007; St. John's, Newfoundland.
28. Quaye S, Fisher Raymond H, Atuahene K, et al. Critique and lessons learned from using multiple methods to estimate population size of men who have sex with men in Ghana. *AIDS Behav*. 2015;19(1):S16–23.
29. Khalid FJ, Hamad FM, Othman AA, et al. Estimating the number of people who inject drugs, female sex workers, and men who have sex with men, Unguja Island, Zanzibar: results and synthesis of multiple methods. *AIDS Behav*. 2014;18(1):25–31.
30. Lee MD, Zhang S, Shi J. The wisdom of the crowd playing The Price Is Right. *Mem Cogn*. 2011;39(5):914–23.
31. UNAIDS/WHO Working Group on HIV/AIDS/STI Surveillance. *Guidelines on estimating the size of populations most at risk to HIV*. 2010:1–51.
32. Statistics Canada. *Visual census*. https://www12.statcan.gc.ca/census-recensement/2011/dp-pd/vc-rv/index.cfm?Lang=ENG&VIEW=D&CFORMAT=jpg&GEOCODE=933&TOPIC_ID=2. Published October 2012. Accessed 15 May 2016.
33. Fenton KA, Johnson AM, McManus S, Erens B. Measuring sexual behaviour: methodological challenges in survey research. *Sex Transm Infect*. 2001;77(2):84–92.
34. Hottes TS, Ferlatte O, Gilbert M. Misclassification and undersampling of sexual minorities in population surveys. *Am J Public Health*. 2015;105(1):e5.
35. Berg N, Lien D. Same-sex sexual behaviour: US frequency estimates from survey data with simultaneous misreporting and non-response. *Appl Econ*. 2007;38(7):757–69.
36. Goldstein ND, Welles SL, Burstyn I. To be or not to be: Bayesian correction for misclassification of self-reported sexual behaviors among men who have sex with men. *Epidemiology*. 2015;26(5):637–44.
37. Ghanem KG, Hutton HE, Zenilman JM, Zimba R, Erbedding EJ. Audio computer assisted self interview and face to face interview modes in assessing response bias among STD clinic patients. *Sex Transm Infect*. 2005;81(5):421–5.
38. van Griensven F, Naorat S, Kilmarx PH, et al. Palmtop-assisted self-interviewing for the collection of sensitive behavioral data: randomized trial with drug use urine testing. *Am J Epidemiol*. 2006;163(3):271–8.
39. Lorenz J, Rauhut H, Schweitzer F, Helbing D. How social influence can undermine the wisdom of crowd effect. *Proc Natl Acad Sci U S A*. 2011;108(22):9020–5.
40. Floyd FJ, Bakeman R. Coming-out across the life course: implications of age and historical context. *Arch Sex Behav*. 2006;35(3):287–96.
41. Rainbow Health Ontario. *LGBT research with secondary data*. http://www.rainbowhealthontario.ca/wp-content/uploads/wocommerce_uploads/2012/10/LGBTQRESEARCHWITHSECONDARYDATA_E.pdf. Published August 2012. Accessed 10 Aug 2016.
42. Walker N, Stover J, Stanecki K, et al. The workbook approach to making estimates and projecting future scenarios of HIV/AIDS in countries with low level and concentrated epidemics. *Sex Transm Infect*. 2004;80(Suppl 1):i10–3.
43. Statistics Canada. *Canadian Community Health Survey—annual component (CCHS)*. <http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3226#a2>. Published June 24 2016. Accessed 10 July 2016.
44. Kendall C, Kerr LRFS, Gondim RC, et al. An empirical comparison of respondent-driven sampling, time location sampling, and snowball sampling for behavioral surveillance in men who have sex with men, Fortaleza, Brazil. *AIDS Behav*. 2008;12(Suppl 4):S97–S104.
45. Lansky A, Abdul-Quader AS, Cribbin M, et al. Developing an HIV behavioral surveillance system for injecting drug users: the National HIV Behavioral Surveillance System. *Public Health Rep*. 2007;122(Suppl 1):48–55.