Epidemiological challenges to the assessment of HIV burdens among key populations: Respondent-driven sampling...

Article in Current opinion in HIV and AIDS · January 2014
DOI: 10.1097/COH.0000000000000046 · Source: PubMed

CITATIONS: 11
READS: 161

2 authors:

Keith M Sabin
UNAIDS
74 PUBLICATIONS 2,856 CITATIONS

Lisa Grazina Johnston
Tulane University
94 PUBLICATIONS 3,229 CITATIONS

Some of the authors of this publication are also working on these related projects:

UNAIDS Key Populations Atlas View project

USAID CAP-3D project View project
<table>
<thead>
<tr>
<th><strong>Manuscript Number:</strong></th>
<th>COH090212R1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full Title:</strong></td>
<td>Epidemiological Challenges to the Assessment of HIV Burdens among key populations: respondent driven sampling, time location sampling and demographic and health surveys</td>
</tr>
<tr>
<td><strong>Article Type:</strong></td>
<td>Review Article</td>
</tr>
</tbody>
</table>
| **Corresponding Author:** | Keith M Sabin, PhD  
UNAIDS  
Geneva, SWITZERLAND |
| **Corresponding Author's Institution:** | UNAIDS |
| **First Author:**      | Keith M Sabin, PhD |
| **Order of Authors:**  | Keith M Sabin, PhD  
Lisa Grazina Johnston, PhD |
Epidemiological Challenges to the Assessment of HIV Burdens among key populations: respondent driven sampling, time location sampling and demographic and health surveys

Authors: Keith M. Sabin\textsuperscript{a} and Lisa G. Johnston\textsuperscript{b}

\textsuperscript{a}Senior Advisor-Epidemiology, UNAIDS, Geneva Switzerland
\textit{corresponding author}
20, avenue Appia
CH 1211 Geneva 27
Switzerland
Tel: +41227915570
email: sabink@unaids.org

\textsuperscript{b}Senior Analyst, Global Health Sciences, University of California, San Francisco

No funding was received to support this work.
Abstract

Purpose of review: Measuring the burden of HIV among key populations is subject to many challenges. Sufficient quantities of valid HIV prevalence and programme coverage data are required to effectively respond to the epidemic.

Recent findings: Innovative use of prostate specific antigen to validate exposure to unprotected sex provides confirmation of condom use. A new weighting scheme based on frequency of venue attendance for time location samples should improve validity of data obtained with this method. Two new proportion estimators, new diagnostic methods, a new population size estimator and new analysis software will provide more robust results from respondent driven sampling.

Summary: Analytical advances have improved the potential quality of results from surveys using time location and respondent driven sampling. However, data from sufficient numbers of sites over sufficient number of years are still needed to provide clear national pictures of distribution and trends of HIV infection.

Keywords: HIV surveillance; respondent driven sampling; time location sampling; key populations
Introduction

An effective national response to the HIV epidemic requires strong prevention, care and treatment programs focused on key populations at risk for HIV exposure. Key populations consist of people who inject illicit drugs (PWID), men who have sex with men (MSM), transgender women and sex workers (SW) and their sex partners. Monitoring HIV prevalence, and access to and utilization of programmes by members of key populations, provides important measures of progress in combating the epidemic. National programmes must “know their epidemic” epidemiologically and programmatically to plan efficiently. The primary means to collect data on these programs is through repeated biological-behavioural surveys.

Programmatically, the measurement of coverage is critical to determine if sufficient numbers of people living with HIV or at risk for contracting HIV are receiving prevention, care or treatment services with intensity adequate to turn or accelerate the epidemic trend downward. For example, if only 30% of PWID know their correct HIV status and routinely access clean needles, it is unlikely that HIV transmission among them will be curtailed. Modelling from Vietnam suggests that programme coverage needs to approach high figures (50% for opiate substitution therapy, 85% to 100% for condom use among SW and regular testing with early treatment) before the epidemic curve moves toward zero. In addition, estimating the population sizes of these populations to comprehend the potential magnitude of the epidemic in each subpopulation is important to planning efforts.

National programs, donors and multilateral agencies use coverage (i.e., condom use, uptake of HIV testing, antiretroviral therapy) measures as a sign of impact of successful responses in reducing HIV transmission.

Overall challenges and Successes

The challenges for collecting and using these important measures can be broken down into two categories. One category is methodological. Probability sampling methods available for surveys of
Key populations have been developed and fielded only in the past 10 years. Key populations are often stigmatized and suffer discrimination in their societies; 60% of countries reporting on legal conditions to UNAIDS have laws, regulations and policies that inhibit access to prevention, care and treatment among key population members. These conditions make these communities difficult to sample in a statistically meaningful way, i.e., with probability sampling. In the mid-1990s, time-location sampling (TLS) (also known as venue-day-time or time-space) adapted multistage cluster sampling to provide a statistical framework for sampling populations that could be mapped. In the early 2000s, respondent driven sampling (RDS) became popular for surveying populations that were socially networked. Analytic advances for both methods permit theoretically unbiased estimators based on probability statistics to be calculated. These methodological advances combined with additional resources for surveys led to an unprecedented expansion of surveys in many populations where data were previously absent. Many of the field methods for implementing TLS or RDS surveys seem to be settled. However, correct analysis of the resulting data remains challenging.

The second category of challenges is overcoming blind spots. While increasing numbers of countries are conducting surveys of key populations, these surveys often cover a small number of localities. Even in countries with large numbers of surveys, like China, Ukraine or Vietnam, surveys are conducted largely in cities. Still, many more cities do not collect any survey data, relying on case reports and little else to monitor the epidemic and response. More commonly, data are available from two or three cities and estimates from these cities are extrapolated or simply applied to represent the entire country. Limits on survey sites generally come from lack of resources to expand and implementation challenges in small towns and rural areas. Some countries make efforts to assess whether the context of one city can be applied to its nearest neighbours; most do not.

Issues that arise in the first category above are being addressed by the academic and survey implementation community. This paper will review some of the notable advances of the past year in this area. The second category is only being acknowledged recently. No publications were
uncovered that discuss this explicitly. However, work from Pakistan suggests that mixed method approaches that include broad area mapping, survey data, and injecting/sexual network data might provide an understanding that is closer to the national picture. In the absence of a nationally distributed surveillance system, widespread HIV testing sites and complete HIV case reporting can provide a full picture of an epidemic.

**Measurement advances**

Much behaviour that puts one at risk for HIV transmission events are considered socially stigmatized in many settings. An on-going challenge is obtaining valid responses to important behavioural questions such as recent opiate use or condom use during sex. Opiate testing of urine specimens is infrequently reported but has been available for a long time. Advances in laboratory testing to confirm validity of responses by use of biological markers are both useful and concerning. Evans et al describe the use of prostate specific antigen (PSA) testing of vaginal swabs collected during a survey of SW to determine recent (<48 hours) exposure to semen. Among women who tested positive for recent exposure to semen (42/183), 42% reported only protected or no sexual intercourse.\(^\text{12}\) Gallo et al review data available on semen biomarkers finding equivocal validity of survey responses.\(^\text{13}\) They suggest pairing analyses of reported condom use with the results of PSA or Y-chromosome DNA testing to assess validity of responses.

**Key populations coverage challenges**

Key population surveys typically cover PWID, MSM and SW. Transgender persons, especially transgender women, were captured primarily within surveys of MSM or SW. Increasingly, surveys of transgender women are reported in the literature and their importance in the required epidemic response is recognized.\(^\text{14}\) Network analysis suggested that RDS could be used successfully to sample transgender women populations\(^\text{15}\) and surveys specifically designed for transgender women have succeeded using RDS.\(^\text{16, 17}\) The Global AIDS Response Progress Report requests selected indicators
be disaggregated by sex, with the option of male, female or transgender woman for the first time in 2014.18

**Geographic coverage challenges**

Survey sampling of key populations typically necessitates adaptive sampling methods, such as TLS or RDS.1 Statistically representative household samples such as the Demographic and Household Surveys are unusual and not recommended for obtaining estimates of prevalence of HIV and associated behaviours.1 Such sampling has low yield of respondents at risk of HIV infection owing to injection drug use, male-male sex or commercial sex, attributable to the relative rarity of these behaviours in the population. Moreover, household survey respondents are often reluctant to divulge practices that might be stigmatized or illegal, especially in a home where relatives might overhear the conversation. In most countries, data are collected from key populations in a limited number of cities. This decision is often based on available resources, conventional wisdom of where populations are located, previous prevalence estimates, where programs are based, and sources of large numbers of case reports. In countries with sufficiently large and diverse survey sites and relatively homogeneous epidemics and responses, estimates may be extrapolated to the unsurveyed portions of the country. Otherwise, if prevention, care and treatment programmes are available, programme data may complement survey data. It is difficult to assess individual site programmes with published aggregated data from multi-site surveys. For example, Kerr et al19 published results from a 10 site survey of MSM and Swarczwald et al20 did likewise for FSW in Brazil. Kerr et al describe important differences among the communities participating in the surveys that would intimate different requirements for programmes in different communities. Emmanuel et al describe results in greater detail, by site, for 20 cites in Pakistan.21 Very clear differences emerge suggesting different responses are necessary and different responses may be in place. It is clear that whatever national policy might exist, needs and/or implementation vary by site and require more granular data.22 These data are also important for measuring trends in HIV prevalence; it is critical to maintain
regular and consistent data collection sites over a period of years to create a clear picture of the epidemic by site and nationally.\textsuperscript{1}

\textbf{Choosing a sampling method}

The decision to choose a sampling method requires understanding the methodology in conjunction with the structure of the population to be surveyed. While there was general agreement that a sampling method once successfully employed should remain in use to allow time trend analysis, there is some agreement that RDS captured harder-to-reach elements of a population. However, rules to select a method were not promulgated though suggestions are available.\textsuperscript{23} A few comparisons to inform sampling method selection were published in the past (See Table 1).\textsuperscript{24, 25} Recently, Paz-Bailey et al published a formal comparison of the two methods to inform the selection of a national methodology for key population surveys in Guatemala,\textsuperscript{26} and Wei et al compared RDS and TLS for sampling black MSM in the United States.\textsuperscript{27} Paz-Bailey found RDS recruited a more diverse, higher risk sample of MSM for lower cost. Design effect was similar for both methods. Wei found a more diverse, higher risk population with RDS and suggests using it for future surveys of black MSM in the United States. Hoang et al report a similar comparison among PWID in Hai Phong, Vietnam, finding similar HIV prevalence, with lower cost and effort per respondent with RDS but higher refusal rates when compared to TLS.\textsuperscript{28}

\textbf{TLS Challenges and Advances}

TLS is the most effective method for obtaining probability samples of populations who can be located at venues. TLS mimics multistage cluster sampling by constructing sampling frames for places where target populations gather in appreciable numbers over different time frames. The estimated numbers in each place-time cell can be used for probability proportional to size sampling. Often the decision to use TLS over RDS is based on history of prior use, familiarity with mapping populations, safety and perception of validity. The similarity between TLS and population
proportional to size cluster sampling provided a strong veneer of statistical validity. However, TLS clusters are typically defined by the very characteristics being measured, giving a likely high level of collinearity within sampling clusters. Karon and Wejnert describe the need to weight TLS samples appropriately by taking into account the frequency of venue attendance and propose methods to do so. Venue-based sampling applied in Tanzania suggests that people who attend more than two social venues per day were more likely to have concurrent sexual partners, highlighting the need to adjust for venue attendance.

**RDS Challenges and Advances**

RDS uses social networks to access members of populations. Recruitment is initiated by selecting a small number of “seeds” (eligible population members). Each seed receives a fixed number of recruitment coupons to recruit his/her peers who then present the coupons at a fixed site to enrol in the survey. Eligible recruits who finish the survey process are also given a set number of coupons to recruit their peers. This process continues until the desired sample size is reached.

A big challenge with RDS is merging statistics with implementation realities. Most RDS estimators are heavily dependent on assumptions of random walk, Markov process models. Specifically that RDS is a sampling with replacement method (the sample size is a small proportion of the population size) and the final sample is independent of the selected seeds. Most empirical explorations to develop more robust statistics attempt to address and provide diagnostics to identify these assumptions. For instance, the Successive Sampling (SS) estimator relaxes the assumptions of a random walk, Markov process model by using a non-replacement sampling successive sampling statistic and having some knowledge of the size of the target population. The model assisted estimator goes one step further by relaxing the replacement sampling and the seed dependence assumptions. Some of these estimators and diagnostic tools have been incorporated into new analysis software.
Another widely explored and difficult to achieve assumption in populations is that respondents are recruited from a peer’s network at random. Additional suggestions for statistics to cope with non-random recruitment offer hope for post hoc adjustments. Another area of discussion among RDS practitioners is the size of design effects used to calculate sample sizes to ensure adequate power and confidence for the sample. Findings from surveys conducted among PWID in the United States and from surveys on multiple key populations in international settings recommend that design effects above two might be adequate for most RDS studies, an effect closer to three or four would be ideal.

**Population size estimations**

Both TLS and RDS can be used in deriving population size estimations of hidden populations by using multiplier methods. The most promising method only using normally collected RDS data uses a Bayesian mathematical solution to estimating the size of key population.

**Summary**

Measuring HIV prevalence among key populations in any epidemic context is an on-going methodological challenge. Many Ministries of Health and public health researchers regularly collect data using probability sampling methods from populations heretofore deemed too difficult to sample with such methods. New analytic and diagnostic tools render these data more validly analysed while laboratory assays permit validation of some critical behavioural questions, giving greater confidence to managers who must make decisions based on these data. The new analytical methods for both RDS and TLS may be initially daunting however the new RDS analysis software should ease the transition to using new estimators. Political will, resources and community engagement are most important to increase the quantity of data to close gaps in knowledge about the epidemic state and local responses to it.

**Key Points: (3-5)**
HIV surveillance among key populations can be achieved using probability sampling methods, specifically respondent driven sampling and time location sampling.

New analytical tools have made the estimates from these methods more robust.

More site specific data are needed for effective local programme planning.

**Acknowledgements:** None
Table 1: Strengths and weaknesses of respondent driven and time location sampling

<table>
<thead>
<tr>
<th></th>
<th>RDS</th>
<th>TLS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strength</td>
<td>Weakness</td>
</tr>
<tr>
<td>Data collection</td>
<td>Recruitment is through peers, enrolment is anonymous, relatively short period of time for data collection†</td>
<td>Population must know each other as member of the target population</td>
</tr>
<tr>
<td>Formative assessment</td>
<td>Requires little formative assessment</td>
<td>Sometimes difficult to identify potential recruitment bottlenecks in the population</td>
</tr>
<tr>
<td>Costs</td>
<td>Found to be less expensive than TLS †</td>
<td>--</td>
</tr>
<tr>
<td>Sample sizes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differences in population characteristics from potential sampling bias</td>
<td>Found to reach more hidden and high risk members of the population,26,27 and those who may have less exposure to programs and services28</td>
<td>May not reach some key members of the target population due to bottlenecks, sometimes difficult to validate membership in the key population</td>
</tr>
<tr>
<td>Analysis</td>
<td>Free analytical software programs and manuals to use those programs</td>
<td>The estimators are mathematically complicated, must use special software; no consensus on how to conduct multivariate analysis</td>
</tr>
</tbody>
</table>

†Recruitment and formative research for RDS was faster than TLS in Wei et al. [6 months for RDS vs. 10 month for TLS]27, Paz-Bailey et al [15 weeks for RDS vs. 16 weeks for TLS]26, and in Hoang et al. [1.5 months for RDS vs. 2.5 months for TLS]28.

‡Paz-Bailey et al found that RDS cost 89 USD and TLS cost 121 USD per participant26; Hoang et al. found that RDS cost 29.4 USD and TLS cost 40 USD per participant.28 Wei et al. do not present cost data.27


10 Karon JM and C Wejnert. Statistical methods for the analysis of time-location sampling data. J Urban Health. 2012; 89(3):565-86. This article is the first to present a weighting method to adjust data collected with time location sampling. The methods should provide estimates with greater validity and appropriate variance.

11 Gile KJ, Johnston LG and M Salganik. Diagnostics for respondent driven sampling. arXiv:1209.6254v1 [stat.ME] Diagnostic tools are presented to test the underlying assumptions for RDS. The tools are simply implemented and will allow researchers to better consider potential biases in their RDS-derived estimates.


UNAIDS. Location, location: Connecting people faster to HIV services. 2013. Geneva, Switzerland

Most at risk populations sampling strategies and design tool: http://globalhealthsciences.ucsf.edu/sites/default/files/content/pphg/surveillance/CDC-MARPs/index.htm.


33 RDS Analyst software can be accessed at http://hpmrg.org/.


36 Wejnert C, Pham H, Krishna N, Let al. Estimating design effect and calculating sample size for respondent-driven sampling studies of injection drug users in the United States. AIDS Behav. 2012; 16(4):797-806. A thorough analysis of two rounds of RDS data collection in 20+ sites shows that design effect is typically between two and four in these populations, for most variables. This is much lower than published theoretical work.

