ESTIMATING THE SIZE AND HIV PREVALENCE OF FEMALE SEX WORKER POPULATIONS IN ZIMBABWE:

GUIDELINES BASED ON STUDIES IN MANICALAND

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Preface

Female sex workers are one of the population sub-groups most vulnerable to HIV infection in sub-Saharan African countries as in much of the rest of the world. In addition, the unique location of female sex workers and their male clients within sexual networks – linking individuals with high-risk behaviour with those with intrinsically lower risk behaviour – means that frequently they play a key role in determining whether HIV epidemics become established and persist within the general population. Therefore it is important to measure and monitor changes in the size of female sex worker populations as well as in HIV infection rates within these populations and associated sexual behaviour so that appropriate control programmes can be developed, implemented and evaluated. With this in mind and to guide the targeting of resources in proportion to the levels of need, UNAIDS have developed and promoted the use of the Modes of Transmission (MOT) Model for estimating the contributions of sex work and other key population sub-groups to on-going transmission of HIV infection.

However, difficulties in measurement have limited the data available on sex worker populations in Zimbabwe and elsewhere. Population size and HIV prevalence estimates based on data from standard general population surveys (e.g. Demographic and Health Surveys) are unreliable because of selective under-enumeration of sex workers due to their higher than average mobility and concealment of sex work activity due to its often illegal (as in Zimbabwe) and highly stigmatised nature. To address these difficulties, a number of methods have been developed for measuring sex worker populations. In these guidelines, we review the various methods that are currently available in the light of previous studies in Zimbabwe and our own experience in conducting research on sex work in the country. We propose a mixed method approach which draws on a combination of PLACE, snowballing and capture-recapture methods and provide guidelines for developing and applying this approach based on a study conducted in four contrasting areas of Manicaland province in eastern Zimbabwe.

The guidelines were developed by the Manicaland HIV/STD Prevention Project research team at the Biomedical Research and Training Institute in Zimbabwe based on original research led by Jocelyn Elmes in the Women at Risk study. Production of the guidelines was funded by the UNAIDS Programme Acceleration Fund through UNFPA Zimbabwe. We are extremely grateful to the following individuals for their valuable contributions to this work: Clemens Benedikt, Adrian Chikeya, Penelope Chirambira, Cynthia Chirwa, Tendai Chowera, Simon Gregson, Timothy Hallett, Ivy, Freedom, Claudius Madanhire, Tidings Masoka, Samuel Mahuntse, Tinashe Mukoki, Reggie Mutsindiri, Kundai Nhongo, Constance Nyamukapa, Masauso Nzima, Peter White, Victor Zhuwau, Lizzy Zinyemba.

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Glossary of Terms

ACASI	Audio computer assisted self-interview
BC	Business or trading centre
BSS	Behavioural Surveillance Survey
C-RC	Capture-recapture
CSW	Commercial sex work(er)
DBS	Dried blood spot
DHS	Demographic health survey
FFI	Face-to-face interview
FHI	Family Health International
FSW	Female sex worker
HIV	Human Immunodeficiency virus
IBBA	Integrated Behavioural and Biological Assessment
ICVI	Informal Confidential Voting Interview
MARP	Most at-risk populations
MOHCW	Ministry of Health and Child Welfare (Zimbabwe)
MSM	Men who have sex with men
NATSAL	National Survey of Sexual Attitudes and Lifestyles
PLACE	Priorities for Local AIDS Control Effort
QQ	Questionnaire
RDS	Respondent driven sampling
R1	Round 1
R2	Round 2
R3	Round 3
SAQ	Self-administered questionnaire
SOP	Standard operating procedures
STD	Sexually transmitted disease
STI	Sexually transmitted infection
SW	Sex worker
TLS	Time-location sampling
VHW	Village health worker
ZDHS	Zimbabwe demographic health survey

1.0 Introduction

1.1 Rationale for Studies on Female Sex Work Estimates

Female sex worker populations, generally, are one of the groups most vulnerable to infection in HIV epidemics. Thus, it is important to identify these populations, estimate their numbers and quantify and understand their levels of risk so that appropriate interventions can be designed, implemented and evaluated. However, in addition, sex work populations can play a disproportionate role in onward transmission of infection and the escalation or perpetuation of HIV epidemics given their central role in sexual networks. Therefore, estimating the size and HIV prevalence of sex work (as well as other most-at-risk) populations (MARPs) is essential to understanding of how HIV epidemics can be controlled.

As infection becomes more widespread, studies based on models of the transmission dynamics of HIV epidemics have shown the relative contribution of sex work to wane (3, 4). These findings suggest that, due to the maturity of the Zimbabwe epidemic and high levels of infection among men and women whose sexual behaviour does not predicate a risk of higher exposure to infection, sustained transmission may occur in the general population independently of SW-client networks (5).

The extent that SW continues to contribute to HIV incidence in mature epidemics is an issue that remains unresolved. Empirical evidence suggests that between 4.4% (6) and 19.6% [10] of new infections in males are attributable to ever paying for sex, findings which the respective authors believe provides evidence that sex work is not and is an important risk factor for HIV infection in mature epidemics. Closer examination of these studies may explain the disparity. Both studies use the population attributable fraction (PAF) for estimating the risk of infection with HIV attributable to a sexual contact with a SW. Firstly, as a fixed measure of risk the PAF fails to account for the spread of disease along sexual networks and therefore may underestimate true risk attributable to SW contacts i.e. for individuals reporting not paying for sex the PAF does not account for infections derived downstream of these non-commercial contacts (which could have been SW contacts if SW is the initial driver of the epidemic). Secondly, the PAF is particularly sensitive to misclassification bias and therefore, any confounders that are not explicitly accounted for or that are poorly measured may influence the estimate (7).

In Zimbabwe, the contribution of sex work to past and contemporary trends at a national level is unclear. Among many behaviour changes associated with recent declines in prevalence, the number of men reporting buying sex halved between 1999 and 2005 (Gregson et al. IJE 2010). However, the extent to which this reduction in risk is linked with a decline in CSW is unknown. Given the high prevalence of HIV in sex workers (SW) (over 55% in rural SW in Mashonaland West, Zimbabwe (8)) and the growing number of women selling sex following deterioration of the Zimbabwean economy (9), it seems plausible that, in

addition to fewer men and women having casual partnerships and increases in condom use, a reduction in visits to CSW could have had a major influence.

Targeting funding resources requires intimate knowledge of the level of need and the quantity needing specific attention. In low-income countries, the HIV epidemic places a considerable burden on already stretched resources. There is therefore a paramount requirement for efficiency and prioritisation when deciding where resources should be directed. In recent years, UNAIDS has promoted a modes of transmission (MOT) modelling process as a part of its 'Know-your-Epidemic Know-your-Response' initiative. In this process, the relative contributions of different sub-populations to the rate of new HIV infections occurring nationally and regionally are estimated in order to better orient funding and intervention promotion to specific groups. The model outputs are sensitive to assumptions made about the size and HIV prevalence amongst key populations including female sex workers and their male clients, so reliable estimates of these numbers are required.

1.2 Purpose and Objectives of these Guidelines

The purpose of this document is to provide guidance on how to conduct studies to estimate the size of female sex worker populations and to obtain HIV prevalence estimates for these populations in contrasting locations in Zimbabwe. It is hoped that the guidelines also may be useful for application in other countries in the sub-Saharan African region.

The specific objectives of the guidelines are:

(i) To outline the alternative methods for measuring sex work populations that have been applied in research studies and to discuss the advantages and disadvantages of these different methods; and

(ii) To describe in detail a mixed method approach to measuring sex work populations which combines elements of the PLACE and snowball methodologies.

In proposing a mixed method approach, it is recognised that, depending on the setting, one of the two main components of the approach may be primary (e.g. in an urban setting, the PLACE component may reach the majority of sex workers, whilst, in a more rural setting, the snowball component may be primary). However, previous research suggests that, in all settings, the combined approach will provide more complete coverage than either of the two component methods applied alone.

It is envisaged that this mixed method approach will provide a cost-effective means of acquiring sex work estimates for use in establishing the contribution of sex work relative to the contributions of other key populations to overall levels of HIV transmission using the Modes of Transmission (MOT) Model developed by UNAIDS.

1.3 Report Outline

The guidelines begin with a chapter (Chapter 2) that reviews the different methods developed for measuring sex work populations including a discussion of alternative definitions and approaches used in obtaining size estimates for and enumerating these populations. The section ends with a rationale for a mixed method approach suitable for measuring and enumerating sex worker populations in Zimbabwe which typically comprise a mixture of visible and more hidden populations. The following chapter (Chapter 3) provides a short review of the rather limited previously published literature on sex worker estimates in Zimbabwe. Chapter 4 sets out guidelines for applying the mixed method approach proposed in Chapter 2, covering the first two main stages – (i) developing the study concept, and (ii) establishing the study design. Chapter 5 covers the third main stage (Implementation) by describing an application of this approach in areas in Manicaland, eastern Zimbabwe. The chapter describes the data collection and data analysis methods that were used in the study and provides details of the resulting estimates.

2.0 Methods for Measuring Sex Work Populations

2.1 Alternative Definitions of Sex Work Populations

There has been some debate in the literature and certainly inconsistency in how to define and characterise sex work (10-12). This has been particularly the case in sub-Saharan African contexts where the boundary between providing money as part of the courtship ritual and providing gifts in exchange for sex has blurred the distinction (13).

Women who self-identify as sex workers may not necessarily share the same client recruitment strategies as women who typify more conventional forms. For example, studies in Burkina Faso (14, 15), Tanzania (16), Kenya (17), China and India (18) have demonstrated that many market traders occasionally engage in commercial sex to provide an additional source of income to their primary trade.

The legislative context surrounding sex work also has a role in the framing of behaviours of sex workers. In Zimbabwe, as in much of sub-Saharan Africa, sex work is illegal and is punishable by a fine and/or up to six months in prison (19). Zimbabwe's sex work industry is consequently, a decentralised and fragmented trade, secreted from public view to avoid prosecution , with no specialised or formal settings for sex work (20); women instead rely on socialising in venues with an ostensibly male patronage offering favourable male : female ratios (21).

Existing studies of SW in Zimbabwe have either concentrated on urban populations (22-24) or visible rural SW within a context of an intervention trial (25). Bars, beerhalls, discos, and

nightclubs have all been identified as places predisposed to attracting SW and their clients and are considered places where high-risk activity is initiated (26-28).

Defining sex work

"No single term adequately covers the range of transactions taking place worldwide that involve sex work. The appropriate term to use for sex work is best defined relative to the local context. This definition may change over time as attitudes evolve" (2)

However, many women who engage in sex exchanges may not identify themselves as sex workers due to stigmatisation, social desirability bias, or because the definition is not sufficiently culturally relevant (29-31). Consequently, the full spectrum of women engaging in risky sexual behaviour is not only under-represented in interventions but also is harder to enumerate and is less well characterised (12, 32, 33). As recognised by UNAIDS, context appropriate definitions of sex work are necessary (2).

Furthermore, the changing economic context in Zimbabwe may also have a role in altering the appropriateness of different definitions of sex work. During the period of economic collapse prior to the introduction of the multi-currency system in 2009, a definition of sex work as an exchange of money or cash for sex may have failed to fully capture the sex worker population.

This manual has been developed primarily to provide guidance on generating estimates of sex worker populations for use in applications of the UNAIDS Modes of Transmission model. Therefore, the standard UNAIDS definition for female sex workers has been used. However, similar methods can be used to estimate the size and HIV prevalence of sex worker populations defined in alternative, possible more locally appropriate, ways.

UNAIDS definition of sex workers (1)

"Female, male and transgender adults and young people (15–24 years) who receive money or goods in exchange for sexual services, either regularly or occasionally"

Enumeration of sex worker populations also requires well-defined geographical delineation. This can be challenged by the mobility of sex workers who have been documented to move into and out of specific areas in response to expected peaks in the client population (34), particularly in response to festivals (35) or public holidays (36). In this manual, we focus on estimates of *de jure* (usually resident) populations of sex workers rather than *de facto* (currently present) populations so as to minimise double-counting. However, this may result in under-estimation of the numbers of female sex workers operating in towns and other locations where there are concentrations of male labour migrants whose usual residence is

in the surrounding areas. Furthermore, it is important to be aware that some size estimation and enumeration strategies are particularly affected by population movement (e.g. capture-recapture – see the following section) and some approaches (such as time-location sampling) may be better suited to enumerating these more transient populations (35, 37).

2.2 Alternative Methods for Measuring the Size of Sex Work Populations

Methods for Estimating the Size of Hidden Populations

Census methods are used widely to obtain estimates of population size at a national level, but, as with general population surveys (such as the demographic and health surveys), they are not well suited to hidden or widely-dispersed populations and are subject to substantial biases (38). This section describes various alternative methods that have been proposed for estimating the size of hard-to-reach populations.

Table 1: Summary of methods to enumerate sex workers (63)

1. *Methods based on targeted data collection from the at risk population*	
Method name	Short description
Census/enumeration	Census counts all members of the population. Enumeration maps an area, counts a fraction of the population in selected areas, and inflates the value to create an estimate.
Capture-recapture	Calculates the total size of a population based on two independent captures of population members. The number of members captured in both samples is used to derive an estimate of the total number in the population.
Multiplier	Compares two independent sources of data for populations to estimate the total number in the population.
2. *Methods based on data collected from the general population*	
Population survey	Includes questions on high risk behaviours in general population survey
Network scale-up	Includes questions on high risk behaviours of respondents' acquaintances in general population survey

Enumeration / census

Typically covering the locations where sex work may be conducted, enumeration involves counting members of the population at randomly-selected or all mapped locations at one time to avoid double-counting (39). Enumeration can be a labour intensive process requiring

a large research team to be deployed simultaneously to different locations within the study area (40). Identification of population members remains an issue if the locations are not specific to sex work, but this can be resolved partially by using key informants from the target population as adjunct researchers to assist in verification (41). Temporal randomisation and repeat enumerations can be used to improve the reliability of the estimate when the numbers of sex workers operating varies depending on temporal factors (e.g. seasonality, paydays, events) (35). Enumeration may be useful for estimating the sizes of visible sex work populations but generally is less effective in situations where many women operate in a non-overt manner.

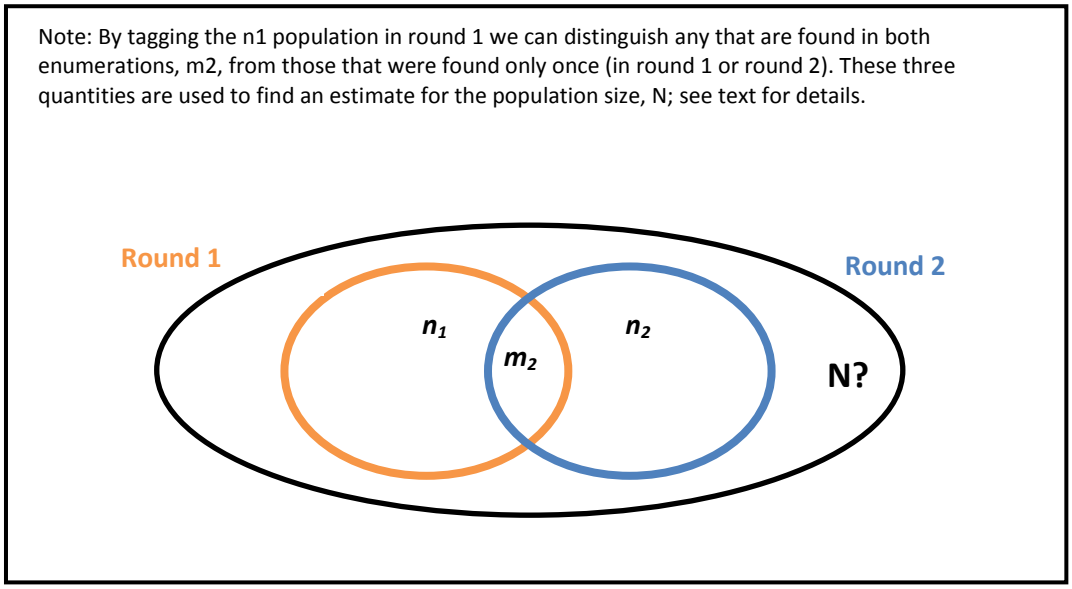
Capture-Recapture

Capture-recapture methods were originally developed as a way to estimate and track animal population sizes in ecology (42). Although specific methodologies have varied, capture-recapture approaches have since been used to enumerate human populations. For example, applied in conjunction with conventional census methods, capture-recapture were used to adjust for under-representation of ethnic minority groups in the 1990 US census (38).

Indirect capture-recapture/multiplier method: In epidemiology, capture-recapture has been recommended for surveillance of uncommon diseases (43) and has been used to estimate the prevalence of both infectious (tuberculosis, malaria) and chronic diseases by comparing two or more data sources from population-based registries, death registries, and hospital inpatient records. This is sometimes alternatively referred to as the multiplier method.

To estimate the size of the HIV positive IDU population in Bangkok, researchers combined lists obtained from IDU treatment centres and police arrests of IDU (44). Alone, any of these lists will underestimate the actual number of cases but, by combining them and identifying entries appearing on more than one list, an estimate of the uncounted cases can be generated (45) (Figure 1). If there is a systematic bias that prevents/enhances membership on one of these lists, however, this will induce a bias in the population estimate. For example, in Chicago, street sex workers who operate through pimps rarely solicit directly on the streets, and consequently experience substantially fewer arrests than their self-employed co-workers; in 88 weeks, there was just 1 arrest among women working for pimps compared to 186 arrests of women who did not (36).

Figure 1: Schematic showing the process of capture-recapture



For many hard-to-reach populations, however, registers are less common and where they exist, are often of questionable quality. Kruse et al. report that, although there is a register of sex workers in Diego Suarez, Madagascar, it is not updated when women die, move out of the city, or cease to sell sex (41). Direct capture-recapture methods may therefore be more suitable for these undocumented populations (41, 46-48).

Direct capture-recapture methods: Mathematically equivalent to the multiplier method, direct capture-recapture is a practical approach to capture-recapture population size estimation. The simplest and most commonly implemented approach for estimating the size of a closed population (closed is defined below) is the Petersen method (42). During round 1 a sample of n_1 individuals is removed from the population; these individuals are marked with a tag that makes them identifiable at a later date and then are returned to the population. After a period of time, which allows for redistribution of marked and unmarked individuals such that they become a homogenous mix, a second sample of the entire population, n_2, is take (this is round 2). It is observed that m_2 individuals captured during the second round are tagged (Figure 1).

If we assume that the proportion of marked individuals in n_2 is a reasonable estimate of the proportion of the total population captured during round 1 (n_1/N), we can equate the two and obtain an estimate of N:

$$\frac{m_2}{n_2} = \frac{n_1}{\hat{N}} \rightarrow \hat{N} = \frac{n_1 n_2}{m_2}$$

There are a number of conditions that need to hold for the method for $\hat{N}$ to be an unbiased estimate of N: these include that the population is closed (i.e. no changes in the population size over the period of sampling); there is no loss of tags; samples are independent; and each individual has an equal probability of capture (see Table 2 for a summary of implications of violating capture-recapture assumptions) (49).

Tags

Tags have two principal functions: during round 1, they act as a guard against double-counting; during round 2, they identify marked individuals from round 1 to the research team. Tagging of human populations is comparatively less straightforward *vis-a-vis* animal populations. While animal tags can be visibly distinguishable to researchers without necessarily introducing bias, the same is rarely true for human populations. Use of visually identifiable marks in human capture-recapture has obvious ethical implications (particularly if the population is stigmatised), so "marking" typically involves the use of a non-visible tag such as a memorable gift or token.

When implementing capture-recapture in human populations, the first and third assumptions frequently are more easily addressed than the other two (50).

Closed populations: For typically mobile populations such as sex workers, it is difficult to eliminate migration to or from the area but a short interval between captures reduces the likelihood this will be a substantial problem (51). Moreover, diminishing the interval between captures also reduces the likelihood of "births" (i.e. new recruits).

Loss of tags: Tags have two principal functions: during round 1, they act as a guard against double-counting; during round 2, they identify marked individuals from round 1 to the research team. Tagging of human populations is comparatively less straightforward *vis-à-vis* animal populations. While animal tags can be visibly distinguishable to researchers without necessarily introducing bias, the same is rarely true for human populations. Use of visually identifiable marks in human capture-recapture has obvious ethical implications (particularly if the population is stigmatised), so "marking" typically involves the use of a non-visible tag such as a memorable gift or token.

Loss of tags is rarely a problem when using pre-existing registries, provided accurate uniquely identifying information is documented. On the other hand, in direct capture samples, tags can be physically lost; for example, if n_1 individuals are required to retain their tags as proof of prior "capture" upon request from research teams in round 2 (48, 52). In other scenarios, loss of tags can have a more abstract meaning where tags are not distinctive

enough to be easily remembered, or where high value items may incentivise low recall (in order to secure a second token within the same round of capture). A variety of tags have been used in previous practical studies including gifts (51), key chains (48), differently coloured cards (52), STI brochures (41) and picture cards (46) to establish recaptures.

Table 2: Assumptions of capture-recapture method and the direction of bias exerted on the population size estimate, $\hat{N}$

Assumption	Violation	Direction of bias	Action/alternative
Closed population	Population mobility in and out of boundary between rounds	In movement -> $\uparrow\hat{N}$ Out movement -> $\uparrow\hat{N}$	• Reduce time between rounds • Note recent mobility on C-RC[‡] questionnaires to remove from numerator
No loss of tags	Individuals misreport receiving health brochure	False positive -> $\downarrow\hat{N}$ False negative -> $\uparrow\hat{N}$	• Take unique identifying information on each person to identify duplicates at analysis stage.
Independence	Probability of recording in R1[†] influences probability of capture in R2 e.g. individuals avoid being interviewed at R2, so-called "trap avoidance"	Avoid recapture -> $\uparrow\hat{N}$ Promote recapture -> $\downarrow\hat{N}$	• Alternate capture days to avoid day-specific biases • Increase time between rounds • Alternate fieldworkers across sites • Use different brochures to reduce trap avoidance (70)
Equal probability of capture	Some individuals are more likely to be caught than others	Deflate the population size estimate	• Repeated capture-recapture rounds and reduce temporal (e.g. seasonal) variability • Enumerate separately distinct populations e.g. the population only in bars

[‡]C-RC refers to capture-recapture

[†]R1 indicates Round 1; similarly, R2 indicates round 2

Guarding against double counting theoretically can be implemented at two stages: during a round or at the analysis stage. During either round of capture-recapture, participants may report that they have already been enumerated and have their tag to show for this (41). Because some tags are high value items (e.g. gifts) they may solicit misreporting of previous encounters to secure additional benefits (41, 46). However, unique objective markers, such as precise recording of clothing and appearance (51), can be used to remove double-counts at the analysis stage. Conventional uniquely identifying information such as full name and birth dates is insufficient in certain populations who, for example, may use pseudonyms to remain unidentifiable or use different names at different times (53). Furthermore, respondents may be unable to provide reliable information (e.g. birth dates in certain contexts are notoriously imprecise (46)).

Independence: This assumption requires that being caught in one sample does not affect the probability of being caught in another sample. If, for example, being in one sample predisposes a subject to be present in a second sample, this will inflate the denominator and therefore underestimate the population size (54). This has been a frequently criticism of capture-recapture models in the literature which has driven the development of statistical approaches to address these concerns. Frank and Snijders, for example, showed that a certain degree of dependence between the lists is tolerated and non-independence is expressed as interaction (55). A practical approach to reduce the dependency in human capture-recapture methods is to increase the duration between rounds, but this has to be balanced by the strategy to ensure the population is closed. To reduce dependency between the rounds, Vuylsteke et al., ran the capture on a Saturday and the recapture on the following Friday. In spite of this precaution, the authors felt their estimates likely underestimated the population size due to women recognising field assistants, thereby promoting recapture (see Table ***Table*** 2 for the implications) (46). This is in contrast to Kruse et al. who found that, during recapture, there was a higher percentage of "trap avoidance" than in the first round: during the second round, 10% of women refused or avoided a second brochure compared to 4% in round 1 (41).

Equal capture probability: Equal capture probability requires that two conditions hold: that individuals from the target population can be identified and that all individuals have the same probability of capture (i.e. n_1 and n_2 samples are taken randomly).

Various examples exist of how to sample hidden populations randomly to satisfy the second condition, such as using a cluster-based random sample or a time-location based random sample. These incur other difficulties and are discussed further in section 3.2.3. Other practical approaches have concerned themselves less with random samples but with a census approach (41). To identify women as sex workers, a number of studies advocate the use of adjunct researchers from the target community to assist in the process (48, 52). Two recent sex worker capture-recapture surveys lauded the employment of sex workers for their unrivalled privileged knowledge of the target population populations (41, 46). The assumption remains, however, that the chosen peers will not miss members due to non-identification.

In practice, the principal concerns for the validity of capture-recapture estimates are the independence of samples and capture probabilities of individuals. Strategies can be implemented to reduce the biases practically and statistically, but, even if the method produces biased estimates, Hook and Regal argue that capture-recapture estimates provide useful upper or lower boundary limits for the population size which can be validated using other size estimation techniques (49).

Network Scale-up

The power of the network scale-up method (NSUM) is that it can be used among non-target members as a way of estimating the size of hidden populations (56). Respondents are asked to enumerate all their contacts that fit into defined groups such as all the people a person knows called Maria, the number of people who have ever been in prison, the number of people who have ever been to a bar to meet sexual partners and so on. By enumerating the size of respondents' social networks and using the weighting of the prevalence of the non-marginalised groups in the general population, an estimate of the size of the at-risk population can be derived. The precision of this estimate is affected by the definition of a contact. This is typically a close friend but not a relative and someone who they have seen in the last 6 months. By calibrating against an individual's personal network of un-stigmatised characteristics, it has been shown that an estimate of size of risk groups can be derived.

Recently this method was used to explore the association of social network characteristics with independent predictors of HIV/STI infection and to therefore validate a venue-based approach to determine sexual risk factors (57). Even in a pared-down survey, administering the questionnaire took 15-20 minutes. While the authors state this was practical and feasible in a socialising situation, questions on other risk behaviours were neglected, and therefore the addition of these could make NSUM prohibitively long for rapid on-site delivery.

Strategies to Recruit Most-at-Risk Populations

Critical issues for studies of sex workers include establishing initial contact with the population and the representativeness of the sample. The illegality of sex work in Zimbabwe and Zimbabwe's Criminal Codification Act[1] precludes organised brothel-based sex work and sex work that can be clearly defined and accessed (23). In the early 1990s, however, bar-based solicitation was common among the sex worker population and peer-education campaigns targeting this group of women achieved high intervention coverage in the population: 80% attended community AIDS meetings, 83% received informal one-on-one peer mediated education, and 90% received condoms in one such programme (24). However, challenges such as the decline in the economy, retrenchment of bars, and a possible concomitant decline in bar-based sex work may make random sampling strategies such as cluster-based sampling at the level of the venue less representative of the current sex worker population. In a more recent analysis of beer hall attendance in Manicaland, although commercial sex was more frequent among women who visited beer halls vis-à-vis women who did not visit beer halls in the previous month, two-thirds of Manicaland women who reported being paid for sex did not report beer hall visits (26). This suggests that the majority of paid sex in Manicaland is no longer associated with venues but is more diffuse and may require additional sampling techniques to reach more hidden sectors of the

[1] The Criminal Law (Codification and Reform) Act [Chapter 9:23] makes it an offence to earn income from a brothel (19)

population. A number of strategies have gained popularity for use with conventionally hard-to-reach populations due to their proximity to randomised sampling (either in method or in generating estimators that can be adjusted for biases at the analysis stage). In this section, classical methods for studying hidden populations and more recent developments in the field, including PLACE (27) and Respondent-driven Sampling (RDS) (58), will be discussed.

Location-Based Sampling

A number of sampling techniques rely on recruiting members of hard-to-reach populations at junctures where either they come into contact with institutions or they are made visible by their work. STI clinics, for example, have provided access to MSM (59) and sex workers (60). Facility or institution-based recruitment, however, is subject to biases including how representative those who are accessed by institutions are of the wider population (e.g. self-selection bias for healthcare seeking behaviour or presentation bias (36)) and may be supplemented by additional outreach work with the target community (61). A powerful sampling technique for sex workers who work in fixed sex work establishments at fixed times, such as a brothel or massage parlour, targets the venue, which represents a "cluster" of sex workers, as the unit of randomisation. Typically clusters will be the places of operation of sex workers rather than their places of residence, though these may co-occur (62).

A more suitable approach for women who work in various, non-specialised locations at different times (e.g. street-based or "floating" sex workers (39)) is a time-location sample (TLS). The clusters of randomisation therefore differ by an additional time dimension (62). Even if these locations are not specialised for sex work per se (e.g. a street) they may be easily identified as known locations for sex work at certain times of the day such as major East-West and North-South roads in Roseland area, Chicago (36) or the Harare Avenues (23). In areas that are not specific to sex work, there is the possibility for misclassification; privileged knowledge of peer researchers may assist in the correct identification of sex workers. As Levitt and Venkatesh note, sex workers advertise their trade to clients by being visible and sticking to specific locations; the need to advertise is reduced when sex work is organised by third parties such as pimps (36).

A methodology that has been growing in popularity in the literature for researching sexual behaviour is the PLACE or Priorities for Local AIDS Control Effort methodology. Devised as an intervention and monitoring strategy for HIV/STI, the method seeks to identify loci where new sexual partnerships are formed (28), under the assumption that these liaisons are the highest risk for HIV infection. This is guided by the principle that the probability of onwards transmission is greatest during acute HIV infection (RR 9.2 compared to the asymptomatic phase (63)). HIV/STI interventions can then be tailored to the specific location where such "high risk" events are most common, thereby reducing the stigmatisation which may follow from defining, identifying, and subsequently targeting high risk individuals (64).

The PLACE methodology is not only a randomisation-based recruitment strategy but, unlike TLS, its integrated intervention design provides a basis for on-going communication with community stakeholders. This continued dialogue with the community may be important to demystify the research process and provide a fertile substrate for mobilisation of community-derived interventions whilst providing an opportunity to deconstruct stigmatising attitudes.

Similarly to TLS, PLACE involves engaging community key informants to identify locations, extensive mapping of these places, and onsite verification (65, 66). Times of operation and approximate capacity of people socialising are noted. The randomisation process differs from TLS such that the unit of randomisation is the individual rather than the time-location cluster; location sizes (determined by the capacity) provide a sampling frame for a fixed interval random sample of individuals (27). It has been suggested that repeated rounds of PLACE could be a method to evaluate behavioural change in target populations (66).

Chain Referral Designs

A potential weakness of the PLACE methodology, which also applies to other location-based methods, is that it targets only those women who recruit clients in visible/public locations (67). These women may not be representative of the entire sex worker population (68).

A number of methods have been developed, however, to study hard-to-reach populations that rely not on external markers of population membership but on the social network that connects population members. These have been used with varying success to sample for enumeration purposes (69, 70), for recruitment into studies (71), or to make inferences about the connections between individuals (72). The most well-known example is “snowball” sampling, a term commonly and confusingly applied to a variety of ascending methodologies (73) across research disciplines. Here snowball sampling refer to the historical precedents for what are more accurately known as chain-referral designs that are widely used in research on hard-to-reach populations (60). Although authors have made an intellectual distinction between the practice of snowball designs and the statistical study of “link-tracing” methods, the unifying principle is that individuals are connected and recruited through social links. For clarity therefore, these methods are referred to here generally as chain-referral designs but the intellectual and practical tensions of the most frequently used designs will also be considered.

Snowball Sampling

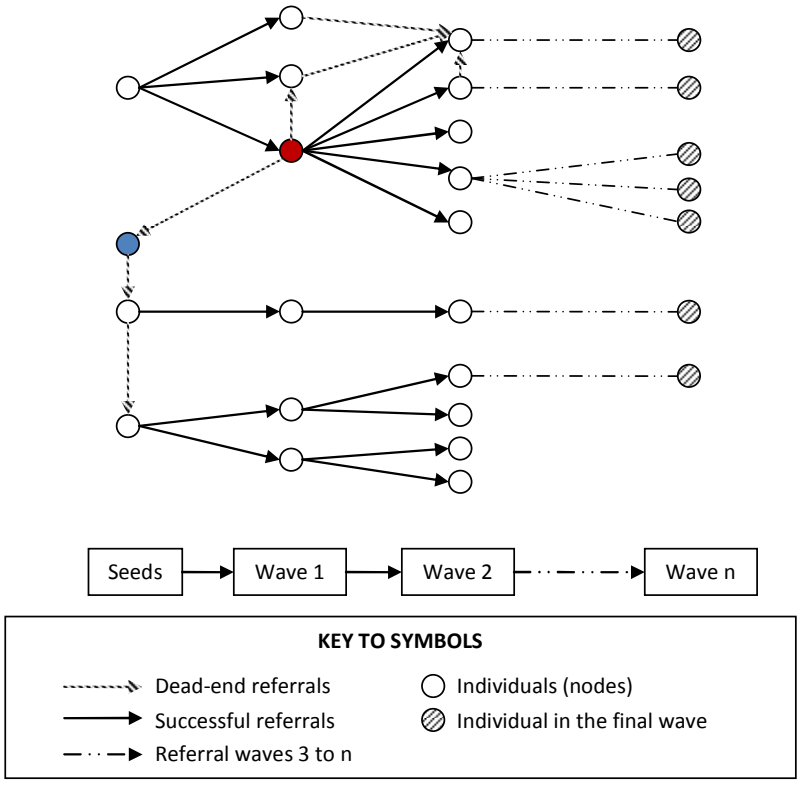
The first use of a chain-referral design was to provide insight into the social connectivity between opinion leaders and followers, dyadic relationships which were poorly represented using conventional sampling techniques (74). The convenience of the strategy for recruiting members of the target population has promoted its use. Although it provides important qualitative insight into the diversity of the underlying population, it was recognised from its

inception that the sample is unrepresentative of true population proportions of various characteristics (74).

The final sample is generated through a series of social connections which extend from an initial group of population members ("seeds") to all other sample members. Individuals at each wave (or referral stage) are asked who they know who belongs to the target population. Individuals not already interviewed thus form the new referral wave; these individuals are sought and asked the same question. Waves of referrals continue until no new individuals are mentioned.

Seeking to gain quantitative insight from the process, Goodman developed the first statistical method for estimating the relational attributes of the final sample. He also illustrated that the "link-tracing" process (or chain referral process) generates a probabilistic sample if initial recruits are selected at random (72). Practically, however, an initial random sample is rarely achievable (75) and, due to the recruitment process, the dependence of final sample estimates on initial subjects means that biases are propagated. Biases include overrepresentation of more cooperative individuals (red node in Figure 2; the converse is the blue seed who nominates no new individuals), social protection of vulnerable subjects or "masking" because the targeted behaviour is stigmatised or illegal, oversampling individuals with larger social networks, and the problem that socially-connected individuals are more alike than would occur by chance (Table 3).

Figure 2: The chain-referral process (see text for details)



Some attempts to address these concerns include limiting the number of nominations any individual can make (thereby preventing over-sampling of any one person's network; the red node in Figure 2 refers 5 individuals which is more than double the simple average number of referrals per node in the first 2 waves[2]) and diversifying the initial recruits (seeds) across different sources such that they are approximately independent (76). Targeted sampling extends this approach with a rigorous ethnographic survey prior to sampling. Though time and resource intensive, this survey identifies subgroups who can be treated as sampling strata within which quota samples are chosen (77).

While the chain-referral approach has gained popularity for its ease of implementation, its non-probabilistic limitations undermine inferences for prevalence estimates to wider disease networks. Even with privileged access to the target population, initial recruitment typically forms a convenience sample due to the problems implicit in trying to access hard-to-reach population members.

A recently developed variant of the snowball method, respondent driven sampling (RDS), was designed to address the bias induced by an initial convenience sample by using statistically valid weights to adjust estimates of population characteristics (Table 3).

Respondent Driven Sampling

Heckathorn showed in 1997 and 2002 (58, 69) that a Markov chain process would evolve under certain conditions, and the stochastic recruitment until equilibrium across unbiased estimators allows for a non-random distribution of seeds. Even if the sampling is biased, the estimators can be corrected if the probability for inclusion in the sample is known (78) and the assumptions of the random walk model are met (Table 3). Despite its widespread popularity (79), there is mounting empirical evidence that questions both the RDS estimators (80, 81) and the process itself (82): specifically, whether the more stringent assumptions are ever met in practice.

Empirical support for RDS has been provided through simulations (83) or through comparison of estimates derived from other frequently used methods such as TLS, snowball sampling or targeted sampling in real-world situations. In the former, the authors simulated an idealised sampling process where all the assumptions of RDS are met; the problem with the latter approach is that, without a gold-standard nor an idea of true population estimates, when there is a discrepancy in the estimates from different methods, it is hard to ascertain whether RDS outperforms its contenders (68). Misleadingly-narrow confidence intervals of RDS estimates can, for example, give the false impression that RDS is superior to its rivals. In a recent assessment of the performance of RDS estimates using computer-simulated chain-referral recruitment, Goel and Salganik suggest that RDS estimates are

2 The average number of referrals per node is 1.6 in this example, calculated from $\frac{\sum referrals}{\sum nodes}$

"substantially less accurate than generally acknowledged"; up to half of true population values of the simulated field studies fell outside the RDS reported confidence interval. The authors note their results likely represent the best possible performance of the RDS weights since the simulated sampling process met all the assumptions of the RDS estimators (Table 3), while, in practice, the assumptions are rarely met (84). The magnitude of bias in the point estimates induced when even mild perturbations are encountered can make adjusted estimates less accurate than the crude sample mean. Moreover, the number of waves of referral to achieve equilibrium across population-level traits in simulation studies exceeds most practical demonstrations of RDS (82).

Table 3: How the Respondent-Driven Sampling (RDS) method addresses biases affecting classical snowball methods

Snowball biases	RDS method	RDS estimator assumptions	Estimator performance
Non-random initial sample	Non-random initial sample	Seed independence through: • Little clustering	 Clustering ↑bias (even when wave # > waves from RDS in real populations)
Seed dependence (biased chain referral)	Long referral chains until equilibrium; discard early waves	• Asymptotic un-biasedness	Bias from 4 waves (20 seeds) > 6 waves (4 seeds) Discarding early waves can ↑bias
		• Connected network	High homophily in connected network increases variance
People with larger networks are more likely to be sampled	Fixed recruitment quota	Random walk model requires: • Small sample fraction	No bias as sample fraction ↑unless differential recruitment activity (↑bias as sample fraction ↑)
	Weights inversely proportional to network degree	• Accurately measure degree	
	Track referrals with coded coupons	• Random referral	Non-random referral has different effects depending on bias in initial sample
		• Ties are reciprocated	Reciprocity can ↑variance in estimator
		• With-replacement sampling	Without replacement performs better
		• Single non-branching chain	
Masking of target members[1]	Financial reward for referring acquaintances, which harnesses social connections between peers to better recruit target members		
Overrepresentation of more cooperative individuals	Recruitment through peers is more successful than researchers directly recruiting		

[1]Masking occurs when recruits deliberately avoid referring certain individuals to the study thereby preserving acquaintances anonymity from the study

A recent important contribution to the methodological debate is a practical assessment of RDS in a known population to estimate the prevalence of a non-stigmatised trait: the proportion of household heads that are male. RDS estimates were validated by true values captured in a household census. The random walk process not only underrepresented young men and those with high socioeconomic status, but, after adjustment with RDS weights, the bias increased: 63%-69% of the unadjusted RDS sample values were closer to the true population proportion than the RDS estimates post-adjustment (81).

A number of empirical examples of RDS cite the practical advantages of the method over alternatives (efficiencies in recruitment (71, 85), wider inclusion over socioeconomic status (68), less stigmatising approach to population members (86) etc.) and the analytical benefits of adjustment when traits are correlated with RDS weights (i.e. network degree) such as for sex work, drug dealing behaviour, and unemployment (80). An important requirement in all chain referral studies is social connectivity and, in poorly networked populations, RDS may not work so well (87, 88). Where the underlying population may be clustered, for example, Gile and Handcock suggest that each subpopulation should be separately seeded to avoid missing these groups which can lead to substantial bias in the estimator (74). Moreover, it is unclear how highly-mobile individuals are represented in such studies. Sex workers, for example, are known to remain in some areas for a short time only such as during periods of high demand – festivals (35), concerts, pay days among others (36); it is conceivable that these mobile workers are not well-known to local people which may inhibit recruitment. Furthermore, even if they are known to the local community, mobile individuals may represent an opportunity cost to the recruiter who could otherwise choose someone more sedentary to ensure their reward.

Population estimates comparable to those from alternative sampling approaches suggest that RDS is at least as good as other methods, and the practical benefits over other methods have seen it implemented widely for studying hard-to-reach populations. Nonetheless, the debate over the performance of RDS - especially vis-à-vis other methods - suggests that RDS is far from being a panacea for sampling of hard-to-reach populations. A number of studies warn against uncritical use and suggest areas for improvement (74, 81, 89, 90).

Summary

Ethnographic studies of sex worker populations have revealed a wide variety of behaviours and associated rituals which cannot be captured comprehensively by any one strategy (91). Moreover, nonresponse may be linked closely with certain methods and subgroups of the target population (92). A major concern for research on hard-to-reach populations is the representativeness of the data. Sampling frames can be developed for women who operate in fixed locations. For more hidden members of the population, chain-referral strategies provide a practical alternative, which in certain situations can be adjusted statistically to allow for known biases in the sampling process. For the population of sex workers in Manicaland, formative research revealed a dichotomisation of sex work between women who recruit clients in drinking venues and more hidden forms (Chapter 2). Targeted

recruitment through a strategy such as PLACE combined with a chain-referral method would allow capture of the variety of sexual exchanges reported in qualitative work.

Bias in Sex Work Estimates and Validation Methods

There are many sources of potential bias in behaviour surveys that come from the sampling procedure, the mode of data collection, the delivery of the questionnaire, and the questionnaire itself (93).

Refusal bias/participation bias

Participation bias reflects the extent to which the achieved sample represents the target population due to differential response rates across population subgroups. In the UK, for example, the overall response rates to a survey of patient health for white men and black or black British men were 61% and 40%, respectively, but were much lower in the youngest age groups (16-35): 30% and 25%, respectively (94).

In hard-to-reach populations, response rates are particularly affected by the extent to which potential respondents are wary of institutions. In countries where sex work is illegal, sex workers may be vulnerable to extortion by authority figures and arrests sometimes occur during research (95). Furthermore, social, religious or cultural taboos surrounding certain behaviours can present a barrier to participation, particularly in rural communities or in a participant's birthplace lest they be discovered for participating. Represented as sex for survival, paid sex in Soweto takes on a functional dimension and therefore may be more acceptable to the community (11) but may be missed by researchers who focus on a Westernised concept of sex work for eligibility.

Individuals engaging in culturally-taboo behaviours which run counter to their own moral norms may feel embarrassed or uncomfortable when confronted with this disparity (cognitive dissonance) when asked to participate in a study of said target behaviour. Striving to reduce such feelings, people can alter their attitudes, beliefs, behaviours; for example, women involved in sex work may dissociate from this description and consequently not report being a sex worker (96). Participation bias may also be related to the timing of survey interviews which can be particularly challenging if the strategy for locating/identifying the target population coincides with their periods of work e.g. interviewing sex workers in their solicitation sites.

Reporting Bias

Cognitive issues influence not only enrolment, but also responses to certain questions once a selected individual agrees to participate. Creative histories of origin of sex work also are a way of distancing oneself from the stigma of sex work and thus form a mechanism for coping with "a spoiled identity" (97).

Social desirability bias also may influence the willingness of participants to respond truthfully in face-to-face interviews (FFI) (98). Moreover, interviewers who are uncomfortable with

certain subject matter may inadvertently provide cues which can make respondents reticent to answer questions faithfully, particularly if they feel the interviewer is disapproving (99, 100). The anonymity of answers afforded by self-administered questionnaires (SAQ), audio computer assisted self-interview (ACASI) or Informal Confidential Voting Interview (ICVI) can reduce embarrassment or social desirability bias and yield higher reports of proscribed behaviours (98, 101, 102). Self-completion modes such as SAQ, however, are subject to substantial survey and item non-response, particularly within a low or middle income country setting (101, 103). Similarly, minority ethnic groups in high income countries exhibit the highest survey and item non-response rates in health surveys (94, 104). Closer examination of reasons for non-response reveal that question or instruction comprehension may be less important than adversity to answer culturally-sensitive questions (101, 105) which, in high income countries with multi-ethnic populations, has prompted cross-cultural adaptation of health surveys (94, 105).

While there are a number of disadvantages of FFI relative to other modes (106), it should be noted that capable interviewers may be able to elicit more faithful and consistent responses by building rapport, particularly during in-depth interviews (107), clarifying answers and correcting inconsistencies (108), reiterating the importance of valid answers and helping respondents relate to the importance of the study. Moreover, in a meta-analysis comparison of four different measures of sensitive behaviour – ever had sex, non-condom use, ever been forced to have sex and number of partners – no interview mode consistently promoted more accurate responses vis-à-vis FFI (109). As multi-mode comparisons testify, there is no manifest gold standard; at an aggregate level, across many questions about sexual behaviour, ACASI may overall deliver lower item non-response and increased reports of sexual behaviours than SAQ and FFI (103). In-depth interviews and participant observations have surpassed ACASI, FFI and SAQ in demonstrating higher consistency in reports and increased reports of risk behaviours (108) but are not feasible on a large scale.

Although the recent meta-analysis of interview modes may be limited by its assumption that the presentation and interpretation of each of the questions was the same across contexts, it demonstrated substantial heterogeneity of effects of interview mode on responses among different demographic groups (110) and across a variety of contexts (109). Therefore, with lack of demonstrable repeatability of effect for any interview mode across contexts, choice of interview mode will need to be locally-appropriate and adequately pretested (111).

An important factor in deciding on the interview mode is the cost-effectiveness of different strategies. Limited evidence on the cost-effectiveness of different survey modes suggests that ACASI is only more cost-effective than SAQ for repeated surveys of large populations (112); however, as explained, SAQ is rarely feasible in low-income countries such as Zimbabwe. At the time of conception, ICVI presented a low-cost, low-technology alternative to ACASI (102) but the growth in affordable smartphones and tablets[3] presents possibilities for more rapid and consistent data collection and data entry (114, 115), with the

[3] Smartphones carrying the Android operating system sufficient for carrying the epicollect application have, at the time of writing, reached $60 (David Aanensen, pers.comm.) and Aakash tablet computers are commercially available for $60 (113)

concomitant advantages that ACASI has over other interview modes, which could be affordable in low income countries.

Modal issues notwithstanding, questions on sexual behaviour do not necessarily yield lower response rates than questions concerning other sensitive issues (93) such as questions about mental health (116); sensitivity to questions is likely to be context specific and questionnaires require pre-testing among members of the target population for culturally appropriate terminology (105, 117, 118).

Aside from the validity problems of self-reported sexual behaviour, even uninhibited interviewees may have trouble recalling frequency of sexual behaviour and the number of sexual partners. Differential saliency of events can have the impact of appearing closer in time or more distant in time than in reality (telescoping effects) (119). If respondents are required to recall a number of events over a given period, the more frequent the occurrences or the longer the period, the more likely the respondent will estimate rather than truly count the occurrences (a process known as decomposition) (99, 120). People with high numbers of sexual partners may have greater difficulty recalling specific acts; substantial discrepancies have been shown between coital diary accounts and weekly recall questionnaires in South African sex workers (121). While coital diaries can be updated on a per-act basis, respondents frequently forget. Combined with the added research burden on respondents, this suggests that coital diaries may be of limited use in long-term prospective data collection (106, 121) although they may play a role in validating frequencies and numbers of sexual contacts over short periods of time in serial cross-sectional surveys (122).

Validation Techniques

The internal consistency of questionnaires and, thus, the reliability of self-reports of behaviour, can be evaluated statistically by assessing the logical continuity of responses between related questions (123) (e.g. Cronbach's alpha statistic for Likert scales (124)) or by conducting repeated interviews within a short period of time (test-retest) and assessing the congruency between reports of time-independent responses (125). External validation can be sought from comparing estimates with other surveys; for example, by triangulating findings of studies in sub-populations with general population surveys. Participation bias is problematic for the overall validity of estimates; special studies of non-participants can be conducted and estimates adjusted accordingly (126), or else, sensitivity analyses of statistical imputations of missing data can provide upper and lower boundaries for estimates (127).

Biological indicators also may be used to validate reports of sexual behaviour. Bioassays that detect STI infections in previously seronegative retest volunteers, for example, can be used to validate reports of consistent condom use over the intervening time between biological testing (128). Currently, all available biomarkers (e.g. pregnancy testing, semen, STI testing) operate on binary indicators of unprotected sex rather than on quantitative measures such as frequency of intercourse. Whilst, STI and pregnancy testing are unable to give a precise measure of how recently unprotected intercourse transpired, testing for prostate-specific antigen (PSA) can reduce this window, as it remains viable for just 48 hours. A recent study

using PSA found substantial under-reporting of recent unprotected sex; 48% of women with biologic evidence of recent semen exposure reported either no sex or condom-protected sex only (129). Nevertheless, biological markers can be costly and time-intensive, particularly if they require swabs, and are not a panacea for validation.

While researchers can attempt to promote faithful reporting of risk behaviours, caveats remain and have led some to question the use of collecting data on behaviour (129). Validation using more time-intensive and costly techniques such as coital diaries or participant observation on a small sample can highlight biases in self-reports which can be explored with sensitivity analyses. Moreover, data on sexual behaviour can at least provide upper and lower bounds for behaviour and these uncertainties can be built into theoretical models of disease dynamics to explore the impact on disease transmission at a population level and the likely implications for public health policy.

2.3 Formative Research

In studies of sex work more generally, formative research to identify the nature of sex work in the particular geographic and social setting is a critical preliminary step. Even where the definition of sex work is narrow and pre-determined (as is the case here), formative research is necessary to guide the development of the detailed study procedures - for example, to clarify how the method of data collection will be applied in the local settings

2.4 Rationale for a Mixed Method Approach

Ethnographic studies of sex worker populations have revealed a wide variety of behaviours and associated rituals which cannot be captured comprehensively by any one strategy (91). Moreover, non-response or participation bias may be linked closely with certain methods of enumeration and subgroups of the target population (92). Mixed method approaches therefore are essential when broad definitions of sex work are used.

Even when narrower definitions such as the UNAIDS definition used here for classical sex work involving exchange of sex for money are applied, multiple methods can be helpful in increasing the completeness of enumeration and the precision of estimates. In the formative research done for the study in eastern Zimbabwe (see section 5), a dichotomisation of sex work was found between women who recruit clients in drinking venues and more hidden forms (e.g. women operating from home) that could not be captured through a single data collection strategy. The defragmented nature of communities challenges the respondent driven sampling approach which requires long chains of referral for the sample to reach equilibrium. Therefore, a strategy of targeted recruitment through a PLACE strategy triangulated with snowballing was developed that allows the various modes of operation identified in the formative research to be captured. This method proved effective in eastern Zimbabwe and is proposed here for wider application and evaluation.

3.0 Previous Research on Female Sex Work Estimates in Zimbabwe

3.1 Sex Worker Population Size Estimates for Zimbabwe

The most recent size estimate studies for sex work populations in Zimbabwe date back to the early-mid 1990s. In 1992, a capture-recapture study was conducted in Bulawayo which estimated the population of women socialising in a random selection of bars as 3894 (95% CI: 4184-3644). The total bar-based sex worker population in Bulawayo was estimated at ~9500 bar-based sex workers; including women who did not solicit in bars, the total sex worker population in Bulawayo was estimated at almost 12,000 (24). A similar capture-recapture study in Mutare, estimated that between 1600 and 2000 women were selling sex over the two weekends of the study (47).

Table 1 summarises the data available on female sex workers populations. The table also includes data from Tete province in Mozambique which lies on a major trucking route from Zimbabwe and where a third of the population attending the clinic were Zimbabwean.

Table 4: Studies measuring the size of female sex worker populations in Zimbabwe

Location	**Year**	**Total pop'n size**	**Female population size** (15-49)	***De facto* pop'n**	***De jure* pop'n**	**SW/female population** (15-49) %	**Method of enumeration**
Chirundu† (34)	1999	2700-4000	1092-1618	100	300	6.2-18.5	Mapping
Beitbridge† (34)	1999	20000	10528	500	700	4.7-6.6	Mapping
Mutare (47)	1993	131,367	66000	1600-2000		2.4-3.0	Capture-recapture
Bulawayo (24)	1994	621742	173,841	9500-12000		5.4-6.9	Mapping and capture-recapture
Mashonaland West (8, 130)‡	2003	2007			363	18	Ethnographic mapping
Tete and Moatize (131)	2008		48,500		4,415	9.1	Mapping and enumeration
†Based on entire female population							
‡Males only							

The ratio of SW to the female population aged 15-49 was based on data in the references where available. Where data were not provided, the size of the female population was obtained from closest of the 1992 and 2002 Zimbabwe national censuses. Where the precise female population size was unavailable, the proportion of the population that was female

was multiplied by the total population size to generate a female population size (Chirundu and Beitbridge[4]).

Successive ZDHS surveys record a drop in the percentage of men aged 15-49 years reporting paying for sex in the last 12 months from 7.2% in 1999 to 3.9% in 2005 followed by a small decline to 3.0% in 2010/2011.

3.2 HIV Prevalence in Zimbabwean Sex Workers

Although no national level statistics on HIV prevalence in women engaging in sex work are available for Zimbabwe, there are a number of localised studies that have reported HIV prevalence in sex workers. These are not directly comparable, however, because they are taken at different stages of the epidemic throughout the country and from different SW sub-populations (e.g. women recruited in bars, women who engage in transactional sex etc.). Female general population prevalence has been taken from 18-49 year-old females from ZDHS and other general population surveys mentioned in the references. HIV prevalence data from STI clinics should be interpreted with caution, particularly if the reason for attendance is due to symptoms. However, the project involved in recruiting attendees engaged in substantial and comprehensive outreach into all SW populations in the clinic ward and all SW were encouraged to attend, regardless of symptoms. A commensurate population is the non-SW female population attendees of the Mbare polyclinic.

[4] The population size for Beitbridge in the census includes non-urban areas so the total population size quoted here is the urban population only as specified by the Corridors of Hope report (34)

Table 5: Studies measuring HIV prevalence in female sex worker populations in Zimbabwe

Year	Location	Population	Age range	HIV prevalence	Female general pop prevalence (18-49)	Reference
1995	Harare (urban)	SW from bars	26.8 (mean) (>18)	86%	27-29% (132)	Ray et al. 2001
2005	Mashonaland West (rural)	Transactional sex workers in mines	18 to 55 (?)	55.7% (50.6-60.9%)	21% (133)	Cowan et al. 2005
1998-2000	Manicaland	Female beer hall visitors in last month	15-44	52.2%	29.9%	Lewis et al. 2005
2010	Harare	SW attending STI clinic	18-49	66%	24% (ANC 2004 (134))	Cowan, pers. comm

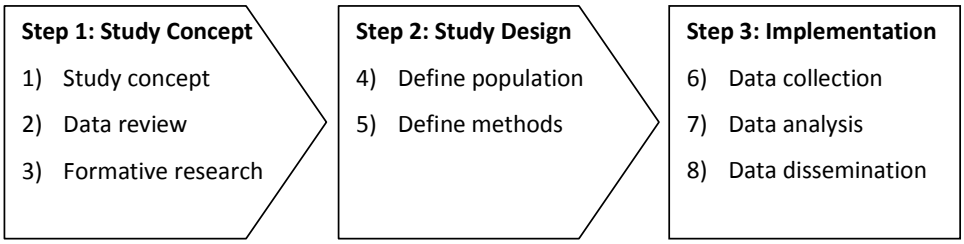
These figures highlight three important aspects of SW in Zimbabwe: first, HIV prevalence in SW is twice that of the general population, which indicates their vulnerability to opportunistic infections and the importance of locating these women for HIV testing; second, the substantial disparity between prevalence in SWs and women in the general population suggests that SW-contacts could still be important in HIV transmission in Zimbabwe; third, this ratifies other findings for a rural epidemic in Zimbabwe and that high risk groups may play a role in transmission in rural societies (135).

4.0 Guidelines on Designing a Mixed Method Study on Female Sex Workers

4.1 Introduction

From conception through to realisation, the implementation of the estimation exercise is a process. Careful preparation and planning will improve the efficiency of data collection and enhance the representativeness of the findings. Figure 3 outlines the three major different stages integral to any population size estimation effort.

Figure 3: Stages in a sex worker population size and HIV prevalence estimation exercise



This section provides guidance on the first two of these three steps. For the third step, an application based on a mixed method approach in Manicaland, eastern Zimbabwe is used as a case study to illustrate the implementation of this process. The methods used and a summary of the results from the study are given in the following section of the manual (section 5).

4.2 Step 1: Development of Study Concept

Identify Study Concept

The first stage is to identify the benefit of enumeration and the purpose of the exercise. A literature review of other sex work population size estimates within the country is essential to establish whether there is a need for the research and whether the expense of conducting primary data collection if justified. At this stage, the exact geographical scope of the project and the precise sex worker group that will be targeted do not need to be fully resolved; however, the literature review and any logistical constraints will narrow the scope to a broad geographical area which will be the focus for the enumeration effort e.g. Bulawayo urban or Beitbridge urban and rural. Formative research can fully resolve the finer geographic and target population details.

Key goals:

- Identify research need
- Outline project aims
- Draft the project scope

Data Review

Once the study has been conceived, existing data on sex workers in the area should be collected and reviewed. First, an inventory of data sources should be established. This may include previously published data and a list of local NGOs that work with sex workers, clinical and health services, the police etc. For example, existing sex worker clinics or outreach programmes may have adequately detailed data from which to derive a multiplier estimate of the population. Second, it is important to clarify whether the data sources are accessible (e.g. clinics may have specific confidentiality concerns). Finally, the quality of available data needs to be evaluated for possible use in the size estimate (e.g. in the multiplier or indirect capture-recapture methods).

Key goals:

- Identify accessible localised data sources
- Establish whether primary data collection is required

Formative Research

To develop a thorough understanding of the nature and characteristics of sex work in the local context, it is important to conduct formative research within the target communities. A diversity of strategies is useful, including informal interviews with local experts (e.g. persons offering health services or who have close contacts with sex worker populations) and focus groups with members of the target population and other community members.

Gaining access to members of the target population can be facilitated by seeking assistance from groups who already work with sex workers. When there are no such groups in the local area, consultations with local community health workers may prove fruitful. Alternatively, it may be best to directly engage sex workers at their place of operation. A rapid appraisal of sex work hotspots and hours of operation through informal interviews with community members who would likely know about sex work (e.g. taxi drivers, bus conductors) can provide such information. Formative research also is a useful prelude to formal mapping approaches as it can provide research teams with a preliminary inventory of the types of locations that are hotspots for sex work in the local context.

For the population of sex workers in the case study areas in Manicaland, formative research revealed a dichotomy of sex work between women who recruit clients in drinking venues and more hidden forms. Moreover, it is important that such prior investigations also include feasibility and situational analyses. In Manicaland, initial enquiries revealed that a single strategy would omit sex workers who did not overlap between the methods. Moreover, due to the defragmented nature of the communities, social networking through RDS would not meet the strict requirements. Therefore, targeted recruitment through a strategy such as PLACE triangulated with snowballing would allow for capture of the variety of sexual exchanges reported in qualitative work.

Key goals:

- Inform the development of a local context-appropriate definition of sex work
- Identify places and times when sex workers recruit clients – types of venue/location and typical hours
- Establish whether hidden sex workers make up a substantial proportion of the sex worker population
- Establish the characteristics of hidden sex workers and how to gain initial access
- Identify community members with insight into sex worker populations
- Establish how sex workers are dispersed across the geographic area and how mobile sex workers are in the study areas
- Complete a risk assessment of night-time access to sex work hotspots
- Inform the optimal design of the detailed data collection strategy and methods

4.3 Step 2: Study Design

Define the Study Population

This includes defining the geographic scope of the study and whether or not to include mobile groups. Clear geographical boundaries will need to be determined. The boundaries to be used will vary according to the objectives of the study but may include administrative boundaries (e.g. ward boundaries or census enumeration areas) or geographical features such as rivers and roads. In rural areas of Zimbabwe, consideration needs to be given to whether villages are a suitable unit for determining study areas since they are often geographically dispersed and sometimes comprise more than one location.

The nature and extent of sex work activity can fluctuate depending on the time of year (holidays, harvest periods etc.). This needs to be taken into account when designing the study (i.e. when is the most appropriate time to conduct the study to meet its particular objectives and in making estimates of likely population size for planning and budget purposes) and later when interpreting the results. Also, drawing on the findings from the formative study, consideration will need to be given to the most suitable days of the week for data collection particularly for the capture-recapture component.

A specific definition of the target population helps to identify the methods that would be most appropriate to enumerate that population. In particular, the age of the target population must be considered; age of majority in Zimbabwe is 18, yet a study in Hwange district found that 15% of 15-19 women reported transactional sex in the past year (69).

Define the Study Methods

Deciding on the composition of the population and the target demographic for the enumeration is a key pre-requisite before choosing the enumeration method. The specific characteristics of the population will determine how effective any particular method is likely to be for the target population. For example, if hidden sex workers do not have a habitual solicitation site, which will likely preclude a solicitation-site-based method of enumerating these women.

5.0 Manicaland Case Study

5.1 Introduction

Table 6 describes the combination of three methods that was used to generate population size and HIV prevalence estimates for female sex worker populations in areas of Manicaland province in eastern Zimbabwe. This mixed-method approach is described in the following sections. The resulting estimates based on the UNAIDS definition of sex work noted in section 2.1 are summarised at the end of the section.

Table 6: Study design components and requirements

Method	Description	Ideal approach	Approach proposed
PLACE	Survey technique for recruiting members of the population - most suitable for visible populations	If sex work services exist, can be used in multiplier method as the representative survey	Assume no sex work services; therefore PLACE used with snowball to approximate a census of the sex worker population
Snowball	Survey technique for recruiting members of the population - suitable for hidden populations		
Capture-recapture	Enumerate venue-based population	Size of the sex worker population in venues	Method used to validate the PLACE estimate for the venue-based sex worker population

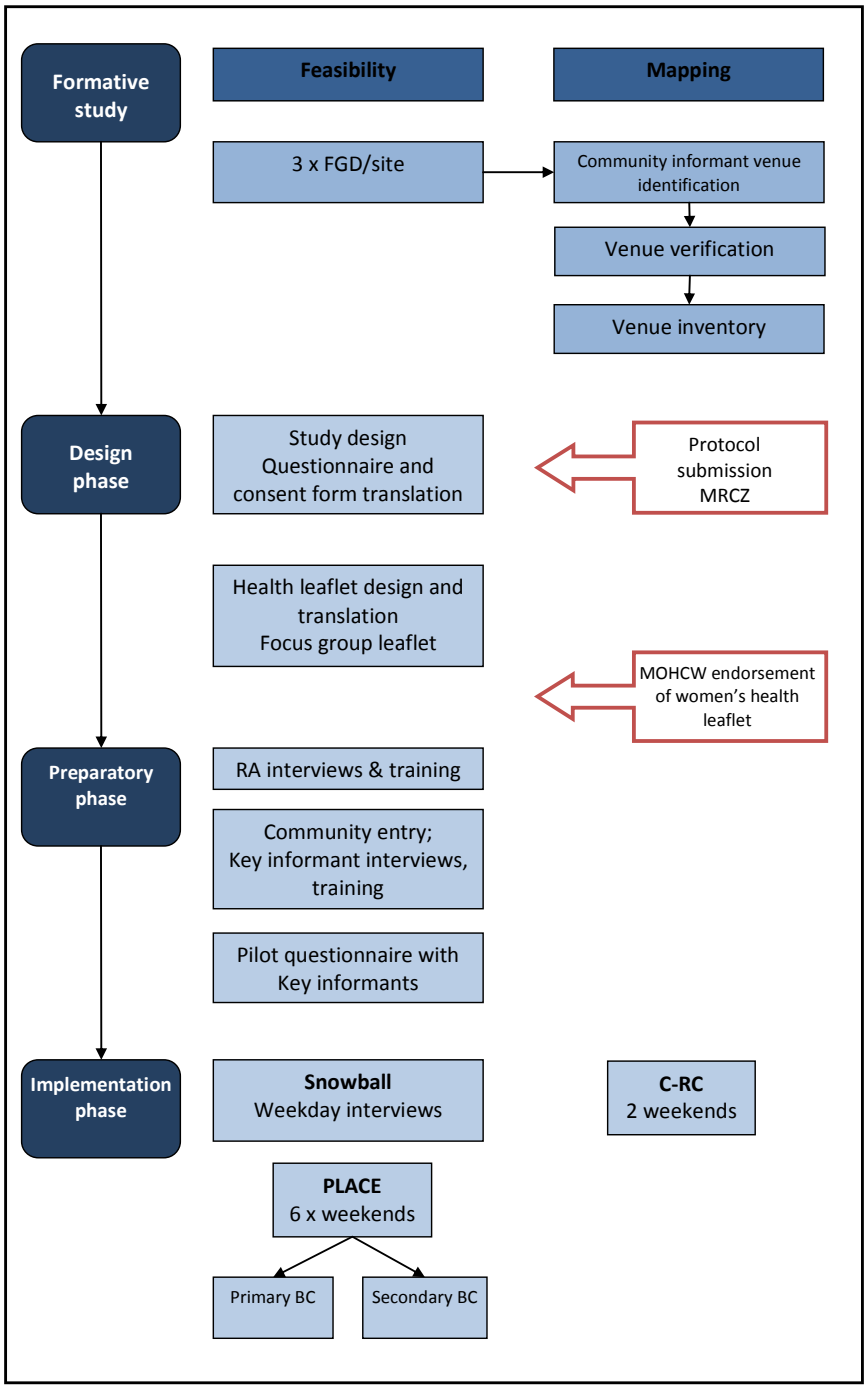
The mixed-method approach used in the SW population size estimation and HIV prevalence study in Manicaland consisted of a combination of PLACE and snowball methods to ensure maximum identification and enumeration of both visible and hidden sub-populations. As noted above, formative research was used to guide the detailed design of the study and decisions about the emphasis to be put on each component given the characteristics of the local context. Capture-recapture was used to validate the completeness of the PLACE estimate for the size of the visible sex worker population.

5.2 Data Collection Methods

An overview of the key stages of the Manicaland study[5] is given in Figure 4 below.

[5] The study in Manicaland (the Women at Risk Study) was designed as a longitudinal prospective survey and utilised a broad definition of sex work. Data on a subset of the women enumerated in the second round of the study who matched the narrower definition* required for the UNAIDS Modes of Transmission (MOT) modelling exercise conducted in Zimbabwe in 2010 were used as the basis for the input assumptions on sex work for the model. To keep things simple in this manual, the methods used in the Women at Risk study have been adapted slightly to match those that would have been used if the study had been a single cross-sectional study and the

Figure 4: Stages of the Manicaland sex work population size and HIV prevalence study



primary objective had been to provide sex worker population size and HIV prevalence estimates for an MOT exercise based on the UNAIDS definition of sex work. *For the 2010 Zimbabwe MOT study, a modified (narrower) version of the UNAIDS definition of sex work was applied.

Preliminary Steps

Mapping of the Study Sites

The study was conducted in four locations – a small town, a large-scale commercial farming estate, a roadside trading settlement, and a subsistence farming area surrounding a mission hospital and school – in northern Manicaland close to the border with Mozambique.

Each site had a principal business centre (BC) which is the main centre of commercial activity. In the town and trading settlement, the principal BCs were lively, comprising a number of shops, bars, restaurants and markets; while, in the rural site and the estate, the principal BCs were much smaller. In addition to the principal BC, clusters of villages were also serviced by a nearby smaller BC providing basic amenities including small bars known colloquially as bottle shops. The principal BCs differ from smaller BCs in the scale and the scope of services and are located typically near or on a major road. In the town, for example, the principal BC was the location for the bus terminus where buses from Harare and Mutare cities would alight to drop off and pick up passengers who lived in nearby villages.

An inventory of venues and events for each of the study areas was developed for the PLACE component by conducting focus group discussions with community members knowledgeable about sex work (e.g. clients, bar attendants, sex workers, market vendors) in which participants were asked to draw maps of the local area and to identify places where sex workers recruit clients and locations where men and women meet for sex. Each location was visited and, where appropriate, the manager or someone onsite was interviewed about the main operating hours and the approximate capacity of the venue at the busiest time. Permission was sought in advance for researchers to enter and approach women socialising in the venues.

Development of Research Instruments

Questionnaires, consent forms, training manuals and standard operating procedures (SOPs) were developed for the study (see Appendix). Individual questionnaires and consent forms were translated into the local language, back-translated and checked.

Ethical Approval

A protocol for the study was developed and submitted for approval to the Medical Research Council of Zimbabwe which included the following arrangements:

Informed Consent: During invitation to join the study, the study was explained to potential participants and it was made clear to them why they had been selected. After the introduction, the procedures and request for a blood sample were explained and potential respondents asked if they would like to participate. All information sheets, consent forms

and questionnaires were translated into Shona. Two copies of consent were signed: one of which was kept by the participant and the other was kept locked in cabinets at BRTI offices.

Harm Minimisation Measures: Attitudes towards sex work often are largely stigmatising, and sex workers are frequently viewed as immoral. Women who have extramarital sex or sex with married men are just as intensely vilified as venue-based sex workers, and, on occasion, are castigated more harshly since sex workers in bars generally use condoms but women having affairs with married men typically do not. In consideration of these beliefs, there is a high possibility of harm being done to participants and of non-response if the study is publicly associated with sex work or extramarital sex. Various measures were taken to reduce this perception within the communities including conducting the study simultaneously with another research general population survey and conducting venue-based PLACE surveys at night.

To reduce the risks to participants, a women's health leaflet was used as the tag in the capture-recapture exercise. To ensure that sex workers are not distinguishable by receiving a health leaflet, additional almost identical leaflets were made available through community health workers and at clinics. The questionnaires, consent forms and blood samples collected by the project were given unique number identifiers and stored securely. Checklists containing information for linking study data to participants' names were stored securely in a separate location. Questionnaire and laboratory test result data were entered into separate tables in the project database. Only senior field-staff, study principal investigators, and authorized collaborators had access to the keys and passwords. Names of individual participants were removed before any copies of or extracts from the data sets were provided to third parties.

Harm Minimisation

Reduce the public profile of the study

- Concurrent with a general population survey
- Same incentives for respondents as for the general population survey
- Preparatory qualitative work with variety of community members not just risk groups
- PLACE conducted at night to reduce community interest

Protect the anonymity of participants

- Peer arrangement for meetings of nominees
- Interview venues in private locations
- Peer facilitators
- Unique number labels for respondents' questionnaires and biomedical samples
- Data and consent forms stored in locked cabinets

Risk Assessment: Standard protocols that included security procedures were developed for all aspects of the study. Conducting research at night time in drinking venues produces an additional level of risk and, although the venues may be well-known to research staff, the unpredictability of the drinking environment necessitated its own precautions. Research assistants were instructed not to approach individuals who are drunk; only male researchers were permitted to enter bars during later evening periods; research teams operated in pairs or larger groups; research assistants were provided with cell-phone air time for emergency use on evening visits; a senior fieldwork supervisor accompanied the research teams during the evening, and remained with the team in the specific locale with project vehicles.

Study Benefits: Participants were compensated for their time and assistance with the research in accordance with MRCZ guidelines. Incentives were not provided but free access to STI treatment and HIV testing services was provided.

Recruitment of Fieldwork Team

The size and composition of the fieldwork team was determined to reflect the size and complexity of the study (see Table 7 below). Male researchers were considered more suitable for recruitment of women in bars for safety and identification purposes but gender-matching was used for the interviews to assist in respondent disclosure.

In addition to the fieldwork managers, supervisors and research assistants, the fieldwork team for the study included adjunct researchers in the form of a team of peer facilitators deployed throughout study sites to assist the research team in engaging with marginalised communities.

Training

In accordance with MRCZ guidelines, all research staff were trained in and required to pass assessments in basic research ethics and good clinical practice. In addition, in light of the sensitivity of the behavioural questions and biological specimen collection, intensive training was carried out prior to the start of data collection. This included conduct and appearance; health and safety at work, accident reporting, and practical training on safe collection of blood samples; and rehearsal of questionnaires and other study tools through role-play. Research staff were provided with training manuals, SOPs, and samples of questionnaires and other study tools for their own reference. The peer facilitators also were trained including on ethical research procedures. The training of the wider research team drew on the local expertise of the peer facilitators who suggested helpful strategies for avoiding adverse events and managing community interest.

Community Entry

To prepare for the arrival of the research team, senior fieldwork staff visited the local community leaders to introduce and explain the nature of the research, and to seek

permission for the study. The local police were notified of the presence of the study in the community. The peer facilitators also assisted with community entry and the conduct of the study.

Implementation

Interview Procedures

The quantitative data were collected in fully-structured face-to-face interviews in suitably private locations using a method designed to reduce social desirability bias (Informal Confidential Voting Interviews (102)) for sections on sexual behaviour and other sensitive personal information.

Biological Specimens

Dried blood spot samples were taken for HIV testing. The research staff were trained on how to take specimens under supervision from the Manicaland project's clinical research supervisor.

Quality Control and Quality Assurance

The quality of the data collected in the field was checked at the end of each day by the fieldwork supervisors for completeness and inconsistencies. Corrections were made by research assistants and, where necessary, clarification was made with study participants; in extreme cases, interviews were repeated. Training was consolidated during fieldwork through direct observation of interviews by senior fieldwork supervisors.

Procedures and Requirements for Individual Study Components

The personnel requirements and study instruments used in the different components of the study in Manicaland are summarised in Table 7. Details of how each component was implemented in the study are given in the following sub-sections.

Table 7: Study components and requirements

Method	Personnel	Instruments
PLACE	2 teams: 1 male RA 1 female RA	Venue log book PLACE questionnaire Appointment cards WR QQ
Snowball	2 teams: 1 male RA 1 female RA	Snowball log book WR QQ
Capture-Recapture	4 teams: 1 nurse 1 RA 1 fieldwork supervisor	C-RC venue log C-RC questionnaire Women's health leaflet Appointment cards

PLACE

Aspects of the PLACE method were implemented to identify and locate public places where sex workers meet new sexual partners. All venues in the principal BCs were covered on weekend evenings during the course of each round. In addition, a simple random sample of smaller BCs in rural areas was taken.

All mapped locations were visited by staff during peak operation hours. Upon entry into a drinking venue, a head-count of all women socialising inside and outside was undertaken to provide a sampling frame and an enumeration estimate for validation through capture-recapture (see below). All women socialising or working on site then were approached individually and invited to join the study and interview onsite. For women who were interviewed on the same night, appointments were made for the following day to collect the DBS samples. Women who declined an interview onsite on the same night were invited for an interview the following day at a more convenient time. Upon agreement, an appointment was made and an appointment card was given. Contact information (cell-phone number, place of residence, friend's cell-phone number) was given to research staff to be able to trace the individuals should they fail to attend for their appointments.

Snowball

Seed selection: To generate a sample that would include members of diverse social groups, seeds were diversified according to several demographic characteristics that in consultation with local sociologists and social workers were identified as distinct social groups. Peer facilitators and focus group participants from the feasibility study in a particular village were thus purposefully selected as seeds to cover a range of demographic characteristics (82)

believed to represent key demographic groups which reflect the diversity of sex work: young sex workers (18-24 years), older sex workers (greater than 25 years), sexually-active widows (136), single mothers (137), and married women engaged in extramarital sex (31). Where possible, one seed matching each of the above demographic characteristics per business centre was selected. This resulted in a total of 32 seeds.

First snowball wave: Seeds were asked to nominate up to ten individuals who they knew well enough to talk with about their sexual encounters and whom they knew to be a sex worker. They also had to be prepared to make an initial approach to inform them of the study. All names were recorded in the snowball log book (Appendix). Each research assistant had a set of ten playing cards which represented the nominees mentioned by their interviewee. To generate a random selection of nominees, the cards were shuffled and the respondent was asked to pick three; these represented the nominees they were asked to approach to meet the research team. The respondent was given up to three appointment cards, one for each of their nominees, each with a unique identifier number relating to the respondent. The unique identifier number was then recorded in the snowball log book next to the nominee for later verification when the nominees arrived for interview. To help identify nominees who came for interview and to avoid duplicates, first name, surname, and then alternative names[6] were recorded in the log book. Each nominator was told that they would receive one bar of soap per nominee, to a maximum of 3, if their nominees were eligible and attended for interview. This token was designed to be small, so as to avoid coercion on the part of the key informants but to compensate them for their efforts in approaching their nominees. Respondents were told that if nominees did not meet the inclusion criteria then they would not be compensated for referral.

Wave propagation: Nominees who attended for interview at the pre-arranged time were checked against the characteristics recorded in the snowball log book to identify to whom the compensation was owed. Interview of nominees proceeded as before but their nominations became the second wave and so on.

Waves were continued until no new nominees were named. Once recruitment chains were thus exhausted, nominees who were not randomly selected with the playing cards were then approached to be interviewed. This way a census of the population could be achieved.

Capture-recapture

Capture and recapture rounds were conducted on consecutive weekends, on a Friday and then on the following Saturday, to maximise independence and to avoid day-specific biases. Capture and recapture brochures were subtly different from one another so that they could

[6] It is common for women to be referred to by a polite name not their first name. Alternatively women may also be referred to by the name of their eldest child e.g. if the eldest child is Sarah the mother may be known as Mai Sarah (mother of Sarah)

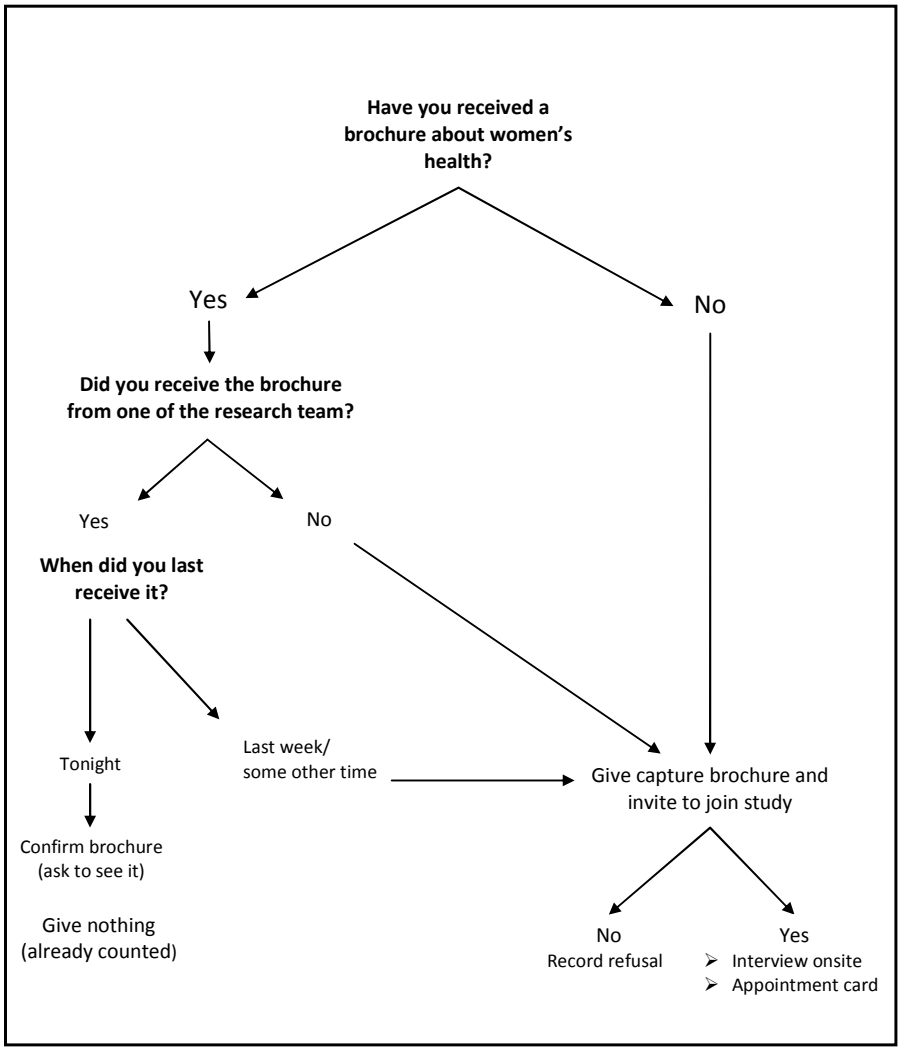
be distinguished by researchers but would not be obviously distinct in a manner that might otherwise identify women as belonging to the study (see Appendix for examples)[7].

Initial capture and mark round: On a Friday night during the middle of the month and following a specified schedule[8], four teams of field researchers visited the mapped venues/locations in each site (one team per site). All women socialising or working inside, or outside in the vicinity of the bar (including all women trading at stalls outside the bars) were approached. Permission was sought to ask a series of questions lasting about 5 minutes. The respondent and researcher would typically move to a quieter area before formal informed consent was requested to conduct the capture-recapture questionnaire (Appendix). During the interview, the respondent was given a small leaflet, the "tag", on women's health (Figure 5). Teams spent 20-30 minutes at each venue.

[7] Text boxes in capture brochures were printed in normal typeface whereas in the recapture brochures, boxes were printed with italicised typeface. In addition, the last page of the capture brochure was numbered C-6 (instead of 6) and the recapture brochure was numbered R-6. It was important to avoid creating brochures that were visibly distinct lest this identified women as belonging to the study. The brochures used for capture-recapture were also distinct from those handed to clinics, key informants and village health workers. These brochures were printed as the capture brochures but the last page was numbered as normal (without a C prefix).

[8] The teams decided on the order that was most geographically efficient, but to observe the busiest periods and venue closing times, those that closed earlier were visited first; some venues did not become busy until other bars started to close: these were visited last. The order of venues was recorded on the venue list.

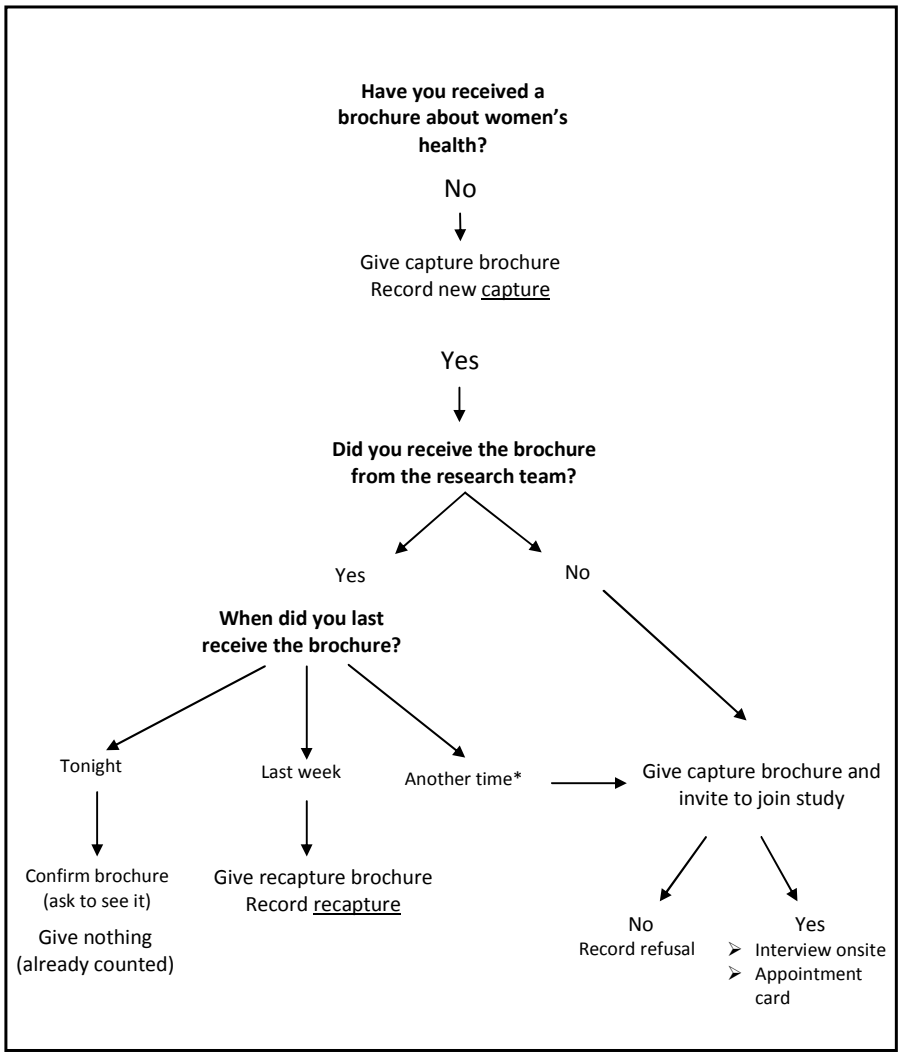
Figure 5: Capture enumeration – flowchart of questions



Second capture and recapture round: A week later, on Saturday at the same time, the researchers revisited the same venues and locations in the same order. The interviewer teams were swapped to avoid interviewer bias[9]. Women were approached as before and asked to take 5 minutes to complete a short survey. During the interview, they were asked if they had received a brochure on women's health the previous week. If they said "no", then the interview proceeded as before in the initial survey; but, if they said "yes", they were asked to recall when they received it and how (Figure 6).

[9] Interviewers were quickly recognised and could promote behavioural avoidance of capture or conversely promote it.

Figure 6: Recapture enumeration



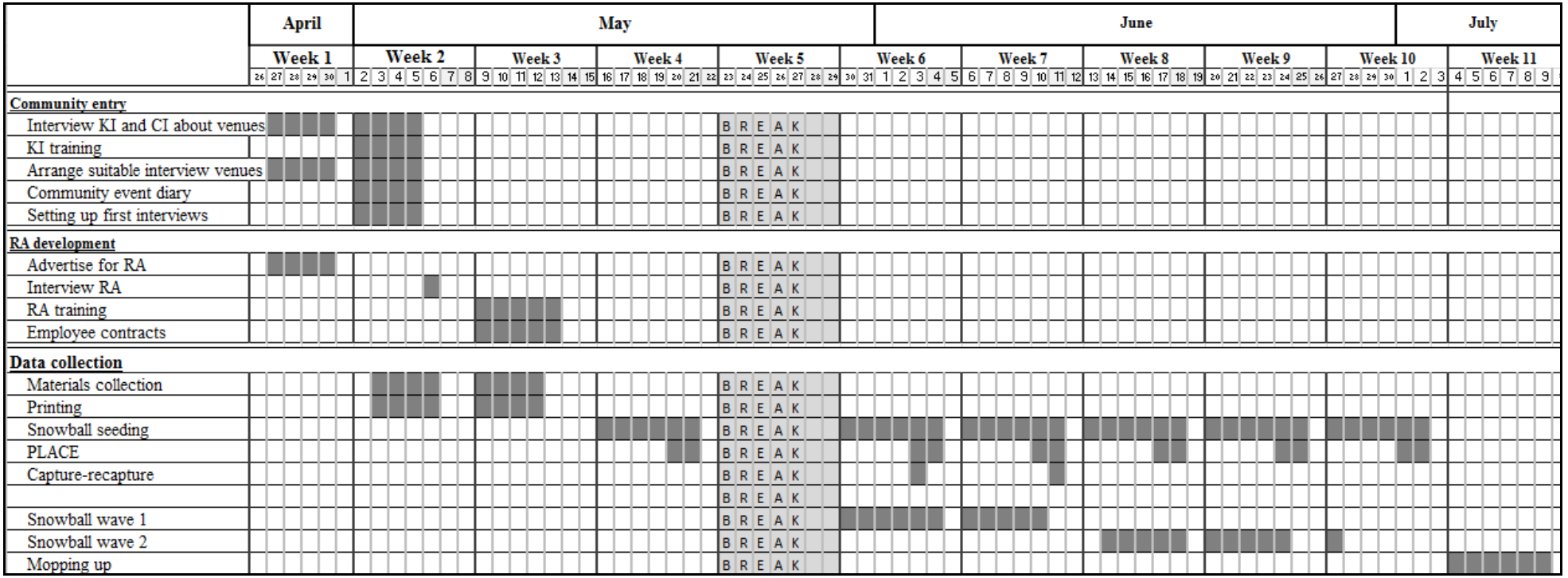
*The timing was confirmed through the C-RC questionnaire; cases when the time was longer than a week were taken as new captures.

If the respondent reported that they had received a brochure earlier that night, the researchers would ask her to produce the brochure so they could verify the answer. If, on the other hand, the woman reported receiving a brochure the previous week, the researcher asked to confirm the brochure and then gave a recapture brochure. If the woman reported receiving the brochure at some other time, the researcher gave the woman a capture brochure and invited her to join the study.

Fieldwork Timetable

The timetable for the fieldwork in the Manicaland sex worker study is shown in the Gantt chart in Figure 7.

Figure 7: Gantt chart showing the fieldwork timetable



5.3 Data Analysis Methods

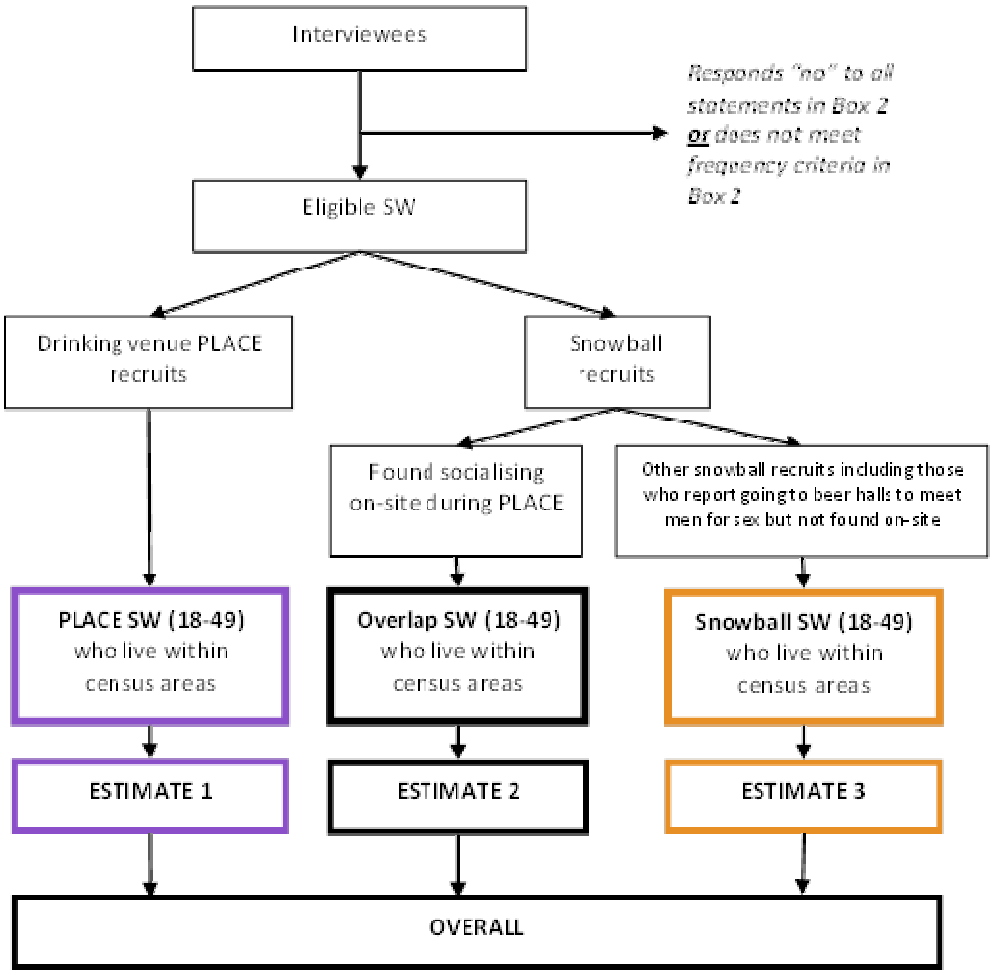
Population Size Estimates

Sex Worker Population Size Estimates based on PLACE and Snowball Methods

Estimates were made for women who usually lived within the study areas and were recruited whilst operating onsite in drinking venues (PLACE) over a 6-week period or through the snowball method (Snowball). The analysis provides estimates for the size of the local sex worker population (Figure 8) based on the numbers found through:

1) PLACE alone
2) Snowball alone
3) Both (overlapping)

Figure 8: Flowchart showing how respondents were categorised in the analysis



To work out the total sex worker by major land-use category, as a proportion of the female population:

$$\frac{\sum_{i=1}^{3} n_i}{\sum_{i=1}^{3} N_i}$$

Where land-use category, i=1,2,3; n_i = number of sex workers (18-49 years) in area i; N_i = females (15-49 years) in area i.

A complete adult census of Manicaland project sites was conducted in 2008 (Laura Robertson *pers. comm.*); the female population (15-49) living in WR project areas from this census forms the denominator.

Capture-Recapture

In addition, data from an application of the capture-recapture method undertaken over two consecutive weekends were used to validate the PLACE estimate for the size of the visible sex worker population.

Chapman's formula was used to calculate a capture-recapture estimate for small populations (42):

$$N = \left\lfloor \frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)} \right\rfloor - 1$$

where n_1 = the number enumerated in the first (Friday night) round; n_2 = the number enumerated in the second (following Saturday night) round; and m_2 = the number enumerated in both rounds.

The approximate unbiased variance estimate proposed by Seber (42):

$$Var(N) = \frac{(n1 + 1)(n2 + 1)(n1 - m2)(n2 - m2)}{(m2 + 1)^2 \cdot (m2 + 2)}$$

was used to derive 95% confidence intervals:

$$N \pm 1.96\sqrt{Var(N)}$$

HIV Prevalence and Sexual Behaviour Estimates

HIV Prevalence

All of the sex workers who participated in the study provided DBS samples for HIV testing. The samples were tested at the BRTI laboratory in Harare using a dipstick dot EIA test (Combaids HIV-1 and HIV-2 Dipstick, India) with high sensitivity and specificity under Zimbabwean conditions (Gregson et al. 2006) to provide estimates of HIV prevalence disaggregated by study location and method of enumeration.

STI Prevalence

Data collected on STIs include self-reported levels of discharge and genital sores. A composite STI symptoms variable was generated comprising reported discharge and/or sores in the last 12 months.

Number of Clients per Year

Sex work clients refer to sexual partners where there is a payment agreement with the partner which is negotiated upfront and in which he agrees to pay at the end of a pre-arranged period or at an agreed frequency.

In the Manicaland sex work study questionnaire, women were asked to report the number of new clients that they had had in the past month. This helped to reduce recall bias but meant that a scaling-up procedure had to be applied to estimate the number of clients they had had in the last year as required for the MOT modelling exercise. The simplest method would have been to scale-up the number of new partners in the past month by a factor of 12 to produce an annual estimate. In reality, for a certain number of weeks each year in the aggregate, women will not have had sex, for example, due to menstruation and illness. To allow for this, we assumed that 4 weeks each year, women do not have sex.

Because there was no direct information on the turnover of regular clients, the total number of current regular clients who they had sex with in the last 12 months (N_r) was added to the total number of new clients in the year ($N_c \, x \, 11$) - equation 1.

$$ppyr = N_c \times 11 + N_r \qquad \text{Equation 1}$$

Number of Sex Acts per Client per Year

It was assumed that, with new clients, women only had one sex act, as these represented one-off encounters (unless they had more than one sex act per encounter and then the number of sex acts was taken to be the number of acts for this partner in the last month).

For regular clients, the number of sex acts in the last month with this partner type was multiplied by 11. If the number of sex acts in the last month was missing, this was taken to be 1.

To calculate the average number of sex acts per client per year, the total number of acts for each partner type was multiplied by the number of partners in the year for each partner type. These two numbers were summed, and then the total was divided by the total number of clients (equation 2).

$$actsppyr = \frac{\left(N_c \times 11 \times A_c + N_r \times A_r\right)}{N_c + N_r} \qquad \text{Equation 2}$$

Percentage of Sex Acts Protected per Client per Year

This was calculated as a percentage:

$$\frac{C}{A} \times 100 \qquad \text{Equation 3}$$

5.4 Results: Population Size and HIV Prevalence Estimates

Population Size Estimates

In total, 376 women meeting the UNAIDS definition for a sex worker were enumerated in the study through the combination of PLACE and snowball methods (Table 8). This was estimated to represent 8.3% of all women resident in the study areas. The prevalence of sex workers was higher in the commercial areas (9.6%) than in the rural areas (7.0%).

Overall, and in both commercial and rural areas, greater proportions of the total estimated number of sex workers were identified through the snowball method than through the PLACE method, suggesting high levels of hidden sex work activity in all of the study areas. Just under 10% of the sex workers enumerated in the commercial areas were only found using the PLACE method. Some of the outlying BCs included in the snowball process were not covered in the PLACE enumeration which will have reduced the size of the PLACE estimate relative to the snowball estimate. However this effect is thought to have been marginal because the numbers of women enumerated using the PLACE method in the outlying BCs were small compared to those enumerated in the principal BCs in each area.

Other factors that may have affected the overall estimates and the comparison of numbers enumerated using the different methods include:

(i) Detailed information was collected on each participant so that few duplicates occurred (n=5, ~1%) and these were easily identified and removed in the analysis.

(ii) Although the PLACE and snowball approaches were applied separately and independently (i.e. women approached through one method also could be found through the other method), the seeds for the snowball process included bar-based women so that bar-based sex workers would be enumerated as part of the process.

(iii) The PLACE enumeration was restricted to evening locations (i.e. drinking locations would have been over-represented and ostensibly day-time locations, such as markets, were under-represented unless they also operated during the night). This was done because it increased the likelihood of capturing the target population whilst reducing the public profile of the project.

Importantly, the mixed-method approach helped to illustrate the direction of bias of any one method applied in isolation. This can be seen as an aid to future size estimation projects to recognise how estimates may be biased and therefore to help decide whether this has implications for the target population. It also highlights the importance of a context-appropriate understanding of sex work and of where and how sex workers operate.

Table 8: Numbers, HIV prevalence and sexual behaviour amongst sex workers enumerated in the Manicaland sex worker study by method of enumeration

(i) Overall

Variable	Overall	PLACE only Estimate 1	Overlap Estimate 2	Snowball only Estimate 3	Manicaland SW
Number	376	24	60	292	108
Female CSW prev	8.31%	0.53	1.3%	6.45%	2.4%
Overall HIV prev	47.6%	60.9%	72.4%	41.5%	37.0%
Overall STI prev (last 12m)	12.3%	12.5%	11.7%	12.5%	15.9%
No. clients per year (mean)	6.98	4.38	8.53	6.87	2.16†
No. acts per partner/year (mean)	2.84	3.55	2.86	2.80	2.14
% acts protected	61%	50%	64%	64%	39%

†An aggregate number of clients were not available so this reflects the total number of different partners (clients and non-clients) over the last year.

(ii) Commercial Areas – Town and Estate

Variable	Total	PLACE only Estimate 1	Overlap Estimate 2	Snowball only Estimate 3	Manicaland SW
Female CSW prev	9.64%	0.89%	2.59%	6.16%	3.0%
Overall HIV prev	56.5%	65.0%	71.9%	48.9%	49.3%

(iii) Rural Areas – Roadside and Subsistence Farming Areas

Variable	Total	PLACE only Estimate 1	Overlap Estimate 2	Snowball only Estimate 3	Manicaland SW
Female CSW prev	7.00%	0.17%	0.09%	6.74%	1.8%
Overall HIV prev	35.3%	33.3%	100.0%	34.9%	17.1%

In Table 8, size estimates for the sex worker populations (expressed as percentages of the total female population) based on data from a general population household survey conducted close to the same time as the sex work study also are compared with those derived using the PLACE and snowball methods. Overall, the household survey estimate is considerably lower (just over a quarter – 2.4% *versus* 8.3%) than that estimated in the sex work study. The household survey performs slightly better in the commercial areas (where more of the sex workers are open about their activities) than in the rural areas. This general pattern is as expected given the stigma associated with sex work in the study areas and the consequent under-reporting of sex work activity expected in household surveys due to social desirability bias.

Table 9 compares the numbers of sex workers visible at bars who were enumerated using the PLACE method with the estimates obtained from the capture-recapture component of the study. The PLACE estimate (54) was somewhat higher than the *de jure* estimate (47) from the capture-recapture process. Although the PLACE estimate fell within the 95% confidence interval obtained for the capture-recapture estimate, a higher figure was expected because the PLACE enumeration extended over a 6-week period whereas the capture-recapture process was completed in two successive weekends.

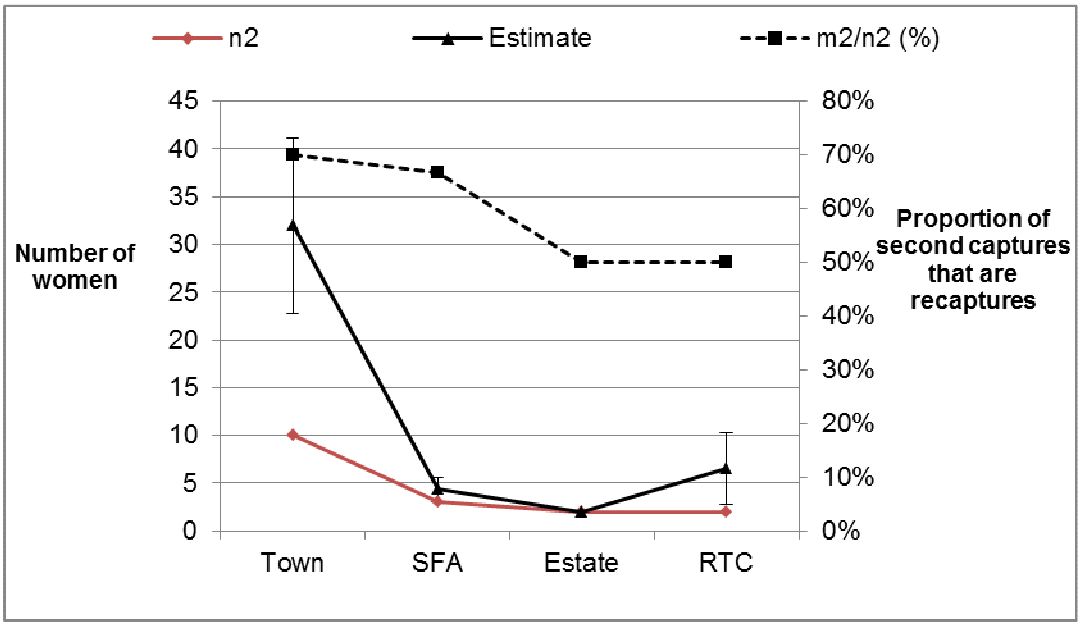
Table 9: Population size estimates for bar-based sex workers: comparison of capture-recapture and PLACE estimates

Capture population	C-RC estimate	
	De Facto	**De Jure**
n1	36	31
n2	22	17
m2	13	11
Overlap	22%	23%
N (95% CI)	60 (45-75)	47 (35-59)
PLACE	-	54

The study samples for the *de facto* population in the capture-recapture exercise violated the assumption of equal catchability as the proportion of marked captures ranged from 43% to 70%. When the *de jure* population is considered, the site-based catchability is somewhat more uniform, ranging from 50% to 70% with two sites achieving 50% and the other two achieving 67% and 70% (Figure 9). Since the town and the subsistence farming area (SFA) were similar in their catchability estimates and the roadside (RTC) and estate areas were also

similar, pooled sub-group estimates were calculated for these two groups and then summed to produce a revised *de facto* estimate of the bar-based sex worker population of 56 (95% CI: 40-72) and a revised *de jure* estimate of the bar-based SW population of 46 (32-60) which account for the differential catchability across sites.

Figure 9: The number of women captured during the second round of C-RC across study sites (red line), the "catchability" (dashed line) and the C-RC estimate of population numbers (solid black line)



Seventy-two per-cent of the women captured in the first round (n_1) reported socialising in the area they were found in for 15-30 nights in the past month. The comparable percentage for the second round (n_2) population was 82%. This population of women therefore is highly immobile with respect to the business centres they frequent over a period of a month, even though two-thirds of the population do not live in the same locale as that in which they socialise. The level of mixing across different business centres by the population was relatively low and at a similar level in each round which indicates that the population is relatively stable and supports the estimate as a reasonable reflection of the numbers socialising in these areas (138).

As noted above, the number of women reached using the PLACE method (n=54) was within the range of the capture-recapture estimate. Moreover, given that the level of mixing between business centres was low, this supports the use of the numbers recruited through PLACE as a valid estimate of the bar-based sex worker population.

HIV Prevalence and Sexual Behaviour Estimates

HIV prevalence in the total sample of female sex workers enumerated in the Manicaland study sites was 47.6% (Table 8). This compared with 37% amongst the women identified as practising sex work in the household survey in the same areas, possibly reflecting selective omission of mobile high-risk SWs in the household survey.

Within the sex work study sample, HIV prevalence was higher in the women enumerated using the PLACE method (69%) than amongst those enumerated using the snowball method (47%). As might be expected, HIV prevalence was higher amongst women enumerated in the commercial areas (56.5%) than amongst those recruited in the rural areas (35.3%).

Twelve per-cent of women in the sex work study reported having experienced symptoms of other STIs within the past 12 months with similar levels being reported by women in the PLACE and snowball samples. The mean number of clients reported per year was 6.98 - higher for the snowball only group than for the PLACE only group but similar when women found through both methods were included in each group (snowball, 7.2; PLACE, 7.3). The mean number of acts of sexual intercourse per partner per year (snowball, 2.8; PLACE, 3.1) and the percentage of sex acts protected using condoms (snowball 64%, PLACE 60%) also were similar for the two groups after including those enumerated in both methods.

6.0 Appendix

References

1. UNAIDS. UNAIDS guidance note on HIV and sex work Geneva: UNAIDS; 2009. 56 p.
2. UNAIDS. Sex work and HIV/AIDS : technical update. Geneva: UNAIDS; 2002. 20 p. p.
3. Boily M-C, Lowndes C, Alary M. The impact of HIV epidemic phases on the effectiveness of core group interventions: insights from mathematical models. Sex Transm Infect. 2002;78(90001):i78-90.
4. Robinson NJ, Mulder D, Auvert B, Whitworth J, Hayes R. Type of partnership and heterosexual spread of HIV infection in rural Uganda: results from simulation modelling. International Journal of Std & Aids. 1999;10(11):718-25.
5. Blanchard JF. Populations, pathogens, and epidemic phases: closing the gap between theory and practice in the prevention of sexually transmitted diseases. Sex Transm Infect. 2002;78(90001):i183-8.
6. Leclerc PM, Garenne M. Commercial sex and HIV transmission in mature epidemics: a study of five African countries. International Journal of Std & Aids. 2008;19(10):660-4.
7. Rockhill B Fau - Newman B, Newman B Fau - Weinberg C, Weinberg C. Use and misuse of population attributable fractions. (0090-0036 (Print)).
8. Cowan FM, Hargrove JW, Langhaug LF, Jaffar S, Mhuriyengwe L, Swarthout TD, et al. The appropriateness of core group interventions using presumptive periodic treatment among rural Zimbabwean women who exchange sex for gifts or money. Jaids-Journal of Acquired Immune Deficiency Syndromes. 2005;38(2):202-7.
9. ZIMBABWE: Sex work thrives as girls struggle to survive IRIN - humanitarian news and analysis. 2007 18 April 2007.
10. Blanchard JF, Khan A, Bokhari A. Variations in the population size, distribution and client volume among female sex workers in seven cities of Pakistan. Sexually Transmitted Infections. 2008;84:II24-II7.
11. Wojcicki JM. Commercial sex work or ukuphanda? Sex-for-money exchange in Soweto and Hammanskraal area, South Africa. Culture Medicine and Psychiatry. 2002;26(3):339-70.
12. Buzdugan R, Halli SS, Cowan FM. The female sex work typology in India in the context of HIV/AIDS. Tropical Medicine & International Health. 2009;14(6):673-87.
13. Decosas J, Padian N. The profile and context of the epidemics of sexually transmitted infections including HIV in Zimbabwe. Sexually Transmitted Infections. 2002;78:I40-I6.
14. Berthe A, Huygens P, Ouattara C, Sanon A, Ouedraogo A, Nagot N. [Understanding and reaching young clandestine sex workers in Burkina Faso to improve response to HIV]. Sante. 2008;18(3):163-73.
15. Nagot N, Ouangre A, Ouedraogo A, Cartoux M, Huygens P, Defer MC, et al. Spectrum of commercial sex activity in Burkina Faso: Classification model and risk of exposure to HIV. Journal of Acquired Immune Deficiency Syndromes. 2002;29(5):517-21.
16. Desmond N, Allen CF, Clift S, Justine B, Mzugu J, Plummer ML, et al. A typology of groups at risk of HIV/STI in a gold mining town in north-western Tanzania. Social Science & Medicine. 2005;60(8):1739-49.
17. Hawken MP, Melis RDJ, Ngombo DT, Mandaliya K, Ng'ang'a LW, Price J, et al. Part time female sex workers in a suburban community in Kenya: a vulnerable hidden population. Sexually Transmitted Infections. 2002;78(4):271-3.
18. Caceres CF. Selection of populations represented in the NIMH collaborative HIV/STD prevention trial - NIMH Collaborative HIV/STD Prevention Trial Group. Aids. 2007;21:S19-S28.
19. Criminal Law (Codification and Reform) Act [Chapter 9:23], Zimbabwe(2004).
20. Wilson D, Wilson C. Knowledge of AIDS among Zimbabwean teacher-trainees prior to the public awareness campaign. Central African Journal of Medicine. 1987;33(9):217-21.

21. NAC, IOM, UNAIDS, UNFPA. Sex work and HIV and AIDS in Zimbabwe: Analysis of current settings, policies and interventions. 2008.
22. Wilson D, Sibanda B, Mboyi L, Msimanga S, Dube G. A pilot study for an HIV prevention programme among commercial sex workers in Bulawayo, Zimbabwe. Social Science & Medicine. 1990;31(5):609-18.
23. Wilson D, Chiroro P, Lavelle S, Mutero C. Sex worker, client sex behaviour and condom use in Harare, Zimbabwe. AIDS Care. 1989;1(3):269-80. Epub 1989/01/01.
24. Ngugi EN, Wilson D, Sebstad J, Plummer FA, Moses S. Focused peer-mediated educational programs among female sex workers to reduce sexually transmitted disease and human immunodeficiency virus transmission in Kenya and Zimbabwe. Journal of Infectious Diseases. 1996;174:S240-S7.
25. Cowan FF, Pascoe SJS, Barlow KL, Langhaug LF, Jaffar S, Hargrove JW, et al. Association of genital shedding of herpes simplex virus type 2 and HIV-1 among sex workers in rural Zimbabwe. Aids. 2006;20(2):261-7.
26. Lewis JJC, Garnett GP, Mhlanga S, Nyamukapa CA, Donnelly CA, Gregson S. Beer halls as a focus for HIV prevention activities in rural Zimbabwe. Sexually Transmitted Diseases. 2005;32(6):364-9.
27. Weir S, Tate J, Hileman SB, Khan M, Jackson E, Johnston A, et al. PLACE: Priorities for Local AIDS Control Efforts. A Manual for Implementing the PLACE Method. The MEASURE Evaluation Project 2005.
28. Weir SS, Pailman C, Mahlalela X, Coetzee N, Meidany F, Boerma JT. From people to places: focusing AIDS prevention efforts where it matters most. Aids. 2003;17(6):895-903.
29. Luke N. Age and economic asymmetries in the sexual relationships of adolescent girls in sub-Saharan Africa. Studies in family planning. 2003;34(2):67-86.
30. UNAIDS. Sex work and HIV/AIDS: UNAIDS Technical Update. 2002.
31. Lurie MN, Williams BG, Zuma K, Mkaya-Mwamburi D, Garnett GP, Sweat MD, et al. Who infects whom? HIV-1 concordance and discordance among migrant and non-migrant couples in South Africa. Aids. 2003;17(15):2245-52. Epub 2003/10/03.
32. Jackson L, Highcrest A, Coates RA. VARIED POTENTIAL RISKS OF HIV-INFECTION AMONG PROSTITUTES. Social Science & Medicine. 1992;35(3):281-6.
33. Aral SO, St Lawrence JS, Tikhonova L, Safarova E, Parker KA, Shakarishvili A, et al. The social organization of commercial sex work in Moscow, Russia. Sexually Transmitted Diseases. 2003;30(1):39-45.
34. FHI. Corridors of Hope in Southern Africa: HIV Prevention Needs and Opportunities in Four Border Towns. 1999.
35. Halli SS, Buzdugan R, Moses S, Blanchard J, Jain A, Verma R, et al. High-risk sex among mobile female sex workers in the context of jatras (religious festivals) in Karnataka, India. International Journal of Std & Aids. 2010;21(11):746-51.
36. Levitt SDaV, Sudhir A. An Empirical Analysis of Street-Level Prostitution. Working Paper2007.
37. Ferreira L, de Oliveira E, Raymond H, Chen S, McFarland W. Use of Time-location Sampling for Systematic Behavioral Surveillance of Truck Drivers in Brazil. Aids and Behavior. 2008;12(0):32-8.
38. Hogan H. The 1990 Post-Enumeration Survey: Operations and Results. Journal of the American Statistical Association. 1993;88(423):1047-60.
39. USAID, IMPACT, FHI, DFID. Behavioural Surveillance Surveys: Guidelines for repeated behavioural surveillance surveys in populations at risk of HIV. 2000.
40. Vuylsteke B, Sika L, Semde G, Thiam M, Traore V, Laga M, et al. Estimating the size of the female sex worker population in three cities in Cote d'Ivoire: results from capture-recapture and other methods. 18th ISSTDR; London2009.
41. Kruse N, Behets F, Vaovola G, Burkhardt G, Barivelo T, Amida X, et al. Participatory mapping of sex trade and enumeration of sex workers using capture-recapture methodology in Diego-Suarez, Madagascar. Sexually Transmitted Diseases. 2003;30(8):664-70.

42. Seber GAF. The estimation of animal abundance and related parameters Griffin; 1973.
43. Forecasting IWGfDMa. Capture-Recapture and Multiple-Record Systems Estimation I: History and Theoretical Development. American Journal of Epidemiology. 1995;142(10):1047-58.
44. Mastro TD, Kitayaporn D, Weniger BG, Vanichseni S, Laosunthorn V, Uneklabh T, et al. Estimating the Number of Hiv-Infected Injection-Drug Users in Bangkok - a Capture-Recapture Method. American Journal of Public Health. 1994;84(7):1094-9.
45. McCARTY DJ, TULL ES, MOY CS, KWOH CK, LAPORTE RE. Ascertainment Corrected Rates: Applications of Capture-Recapture Methods. International Journal of Epidemiology. 1993;22(3):559-65.
46. Vuylsteke B, Vandenhoudt H, Langat L, Semde G, Menten J, Odongo F, et al. Capture–recapture for estimating the size of the female sex worker population in three cities in Côte d'Ivoire and in Kisumu, western Kenya. Tropical Medicine & International Health. 2010;15(12):1537-43.
47. Watts C, Zwi A, Wilson D, Mashababe S, Foster G. Capture-Recapture as a Tool for Program-Evaluation. Br Med J. 1994;308(6932):858-.
48. Paz-Bailey G, Jacobson JO, Guardado ME, Hernandez FM, Nieto AI, Estrada M, 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. Sexually Transmitted Infections. 2011;87(4):279-82.
49. Hook EB, Regal RR. The Value of Capture-Recapture Methods Even for Apparent Exhaustive Surveys. American Journal of Epidemiology. 1992;135(9):1060-7.
50. Gutteridge W, Collin C. Capture-Recapture Techniques - Quick and Cheap. Br Med J. 1994;308(6927):531-.
51. Watts CH, Zwi AB, Foster G. How to do (or not to do)...Using capture-recapture in promoting public health. Health Policy and Planning. 1995;10(2):198-203.
52. Khan SI, Bhuiya A, Uddin AS. Application of the capture-recapture method for estimating number of mobile male sex workers in a port city of Bangladesh. J Health Popul Nutr. 2004;22(1):19-26. Epub 2004/06/12.
53. Black JFP, Mclarty DG, Mtasiwa D. Capture-Recapture Techniques - Difficult to Use in Developing-Countries. Br Med J. 1994;308(6927):531-.
54. Bloor M, Wood F, Palmer S. Use of mark-recapture techniques to estimate the size of hard-to-reach populations. J Health Serv Res Policy. 2000;5(2):89-95. Epub 2000/08/18.
55. Frank O, Snijders GF. Estimating the Size of Hidden Populations Using Snowball Sampling. Journal of Official Statistics. 1994;10(1).
56. Killworth PD, Johnsen EC, McCarty C, Shelley GA, Bernard HR. A social network approach to estimating seroprevalence in the United States. Social Networks. 1998;20(1):23-50.
57. Drumright LN, Frost SD. Rapid social network assessment for predicting HIV and STI risk among men attending bars and clubs in San Diego, California. Sex Transm Infect. 2010;86 Suppl 3:iii17-23. Epub 2010/10/23.
58. Heckathorn DD. Respondent-driven sampling II: Deriving valid population estimates from chain-referral samples of hidden populations. Social Problems. 2002;49(1):11-34.
59. Gerver SM, Easterbrook PJ, Anderson M, Solarin I, Elam G, Fenton KA, et al. Sexual risk behaviours and sexual health outcomes among heterosexual black Caribbeans: comparing sexually transmitted infection clinic attendees and national probability survey respondents. International Journal of Std & Aids. 2011;22(2):85-90.
60. Atkinson R, Flint J. Accessing Hidden and Hard to Reach Populations: Snowball Research Strategies. Social Research Update. 2001;33.
61. Ward H, Day S, Weber J. Risky business: health and safety in the sex industry over a 9 year period. Sexually Transmitted Infections. 1999;75(5):340-3.
62. International ICoMRFH. National Interim Summary Report, Round 1 (2005 - 2007). Indian Council of Medical Resaerch & Family Health International, 2007.

63. Boily M-C, Baggaley RF, Wang L, Masse B, White RG, Hayes RJ, et al. Heterosexual risk of HIV-1 infection per sexual act: systematic review and meta-analysis of observational studies. The Lancet Infectious Diseases. 2009;9(2):118-29.
64. Anderson RM. Transmission of sexually transmitted infections. In: Holmes KK, editor. Sexually transmitted diseases. 3rd ed. ed. New York ; London: McGraw-Hill, Health Professions Division; 1999. p. pp 25-37.
65. Singh K, Sambisa W, Munyati S, Chandiwana B, Chingono A, Monash R, et al. Targeting HIV Interventions for Adolescent Girls and Young Women in Southern Africa: Use of the PLACE Methodology in Hwange District, Zimbabwe. AIDS Behav. 2009. Epub 2009/05/20.
66. Weir SS, Tate JE, Zhusupov B, Boerma JT. Where the action is: monitoring local trends in sexual behaviour. Sex Transm Infect. 2004;80 Suppl 2:ii63-8.
67. Weir S. Comparison of venue-based and respondent driven sampling methods for surveillance of sex workers. 19th ISSTDR; Quebec city, Canada2011.
68. Kendall C, Kerr L, Gondim RC, Werneck GL, Macena RHM, Pontes MK, 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 and Behavior. 2008;12(4):S97-S104.
69. Heckathorn DD. Respondent-driven sampling: A new approach to the study of hidden populations. Social Problems. 1997;44(2):174-99.
70. Davis WR, Johnson BD, Randolph D, Liberty HJ. An enumeration method of determining the prevalence of users and operatives of cocaine and heroin in Central Harlem. Drug Alcohol Depend. 2003;72(1):45-58.
71. Platt L, Wall M, Rhodes T, Judd A, Hickman M, Johnston LG, et al. Methods to recruit hard-to-reach groups: Comparing two chain referral sampling methods of recruiting injecting drug users across nine studies in Russia and Estonia. Journal of Urban Health-Bulletin of the New York Academy of Medicine. 2006;83(6):I39-I53.
72. Goodman LA. Snowball Sampling. The Annals of Mathematical Statistics. 1961;32(1):148-70.
73. Mavhu W, Langhaug L, Pascoe S, Dirawo J, Hart G, Cowan F. A novel tool to assess community norms and attitudes to multiple and concurrent sexual partnering in rural Zimbabwe: participatory attitudinal ranking. AIDS Care. 2011;23(1):52-9. Epub 2011/01/11.
74. Handcock MS, Gile KJ. COMMENT: ON THE CONCEPT OF SNOWBALL SAMPLING. Sociological Methodology. 2011;41(1):367-71.
75. David B, Snijders TAB. Estimating the size of the homeless population in Budapest, Hungary. Quality & Quantity. 2002;36(3):291-303.
76. Langhaug LF, Cheung YB, Pascoe SJ, Chirawu P, Woelk G, Hayes RJ, et al. How you ask really matters: randomised comparison of four sexual behaviour questionnaire delivery modes in Zimbabwean youth. Sex Transm Infect. 2011;87(2):165-73. Epub 2010/10/15.
77. Watters JK, Biernacki P. Targeted Sampling: Options for the Study of Hidden Populations. Social Problems. 1989;36(4):416-30.
78. Thompson SK. Adaptive sampling in behavioral surveys. NIDA Res Monogr. 1997;167:296-319. Epub 1997/01/01.
79. Malekinejad M, Johnston LG, Kendall C, Kerr L, Rifkin MR, Rutherford GW. Using respondent-driven sampling methodology for HIV biological and behavioral surveillance in international settings: A systematic review. Aids and Behavior. 2008;12(4):S105-S30.
80. Goel S, Salganik MJ. Assessing respondent-driven sampling. Proceedings of the National Academy of Sciences. 2010;107(15):6743-7.
81. McCreesh N, Frost SD, Seeley J, Katongole J, Tarsh MN, Ndunguse R, et al. Evaluation of Respondent-driven Sampling. Epidemiology. 2012;23(1):138-47. Epub 2011/12/14.
82. Gile KJ, Handcock MS. RESPONDENT-DRIVEN SAMPLING: AN ASSESSMENT OF CURRENT METHODOLOGY. Sociological Methodology. 2010;40(1):285-327.

83. Volz E, Heckathorn DD. Probability Based Estimation Theory for Respondent Driven Sampling. Journal of Official Statistics. 2008;24(1):79-97.
84. Malekinejad M, Johnston L, Kendall C, Kerr L, Rifkin M, Rutherford G. Using Respondent-Driven Sampling Methodology for HIV Biological and Behavioral Surveillance in International Settings: A Systematic Review. Aids and Behavior. 2008;12(0):105-30.
85. Robinson WT, Risser JMH, McGoy S, Becker AB, Rehman H, Jefferson M, et al. Recruiting injection drug users: A three-site comparison of results and experiences with respondent-driven and targeted sampling procedures. Journal of Urban Health-Bulletin of the New York Academy of Medicine. 2006;83(6):I29-I38.
86. Lee R, Ranaldi J, Cummings M, Crucetti JB, Stratton H, McNutt L-A. Given the Increasing Bias in Random Digit Dial Sampling, Could Respondent-Driven Sampling be a Practical Alternative? Annals of Epidemiology. 2011;21(4):272-9.
87. Evans A, Hart G, Mole R, Mercer C, Parutis V, Gerry C, et al. Central and East European migrant men who have sex with men in London: a comparison of recruitment methods. BMC Medical Research Methodology. 2011;11(1):69.
88. Paquette D, Bryant J, de Wit J. Respondent-Driven Sampling and the Recruitment of People with Small Injecting Networks. Aids and Behavior.1-10.
89. Heimer R. Critical issues and further questions about respondent-driven sampling: Comment on Ramirez-Valles, et al. (2005). Aids and Behavior. 2005;9(4):403-8.
90. Salganik MJ. Commentary: Respondent-driven Sampling in the Real World. Epidemiology. 2012;23(1):148-50. Epub 2011/12/14.
91. Aral SO, St Lawrence JS. The ecology of sex work and drug use in Saratov Oblast, Russia. Sexually Transmitted Diseases. 2002;29(12):798-805.
92. Magnani R, Sabin K, Saidel T, Heckathorn D. Review of sampling hard-to-reach and hidden populations for HIV surveillance. Aids. 2005;19:S67-S72.
93. Fenton KA, Johnson AM, McManus S, Erens B. Measuring sexual behaviour: methodological challenges in survey research. Sexually Transmitted Infections. 2001;77(2):84-92.
94. Europe PI. Increasing Response Rates Amongst Black and Minority Ethnic and Seldom Heard Groups: A review of literature relevant to the National Acute Patients' Survey. Oxford: Picker Institute Europe, 2007.
95. Elmore-Meegan M, Conroy RM, Agala CB. Sex workers in Kenya, numbers of clients and associated risks: An exploratory survey. Reproductive Health Matters. 2004;12(23):PII S0968-8080(04)23125-1.
96. Wojcicki JM. "She drank his money": Survival sex and the problem of violence in taverns in Gauteng Province, South Africa. Medical Anthropology Quarterly. 2002;16(3):267-93.
97. Campbell C. Selling sex in the time of AIDS: the psycho-social context of condom use by sex workers on a Southern African mine. Social Science & Medicine. 2000;50(4):479-94.
98. Ghanem KG, Hutton HE, Zenilman JM, Zimba R, Erbelding 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. Epub 2005/10/04.
99. Catania JA, Gibson DR, Chitwood DD, Coates TJ. Methodological problems in AIDS behavioral research: influences on measurement error and participation bias in studies of sexual behavior. Psychol Bull. 1990;108(3):339-62. Epub 1990/11/01.
100. Bowling A. Mode of questionnaire administration can have serious effects on data quality. Journal of Public Health. 2005;27(3):281-91.
101. Langhaug LF, Cheung YB, Pascoe SJS, Chirawu P, Woelk G, Hayes RJ, et al. How you ask really matters: randomised comparison of four sexual behaviour questionnaire delivery modes in Zimbabwean youth. Sexually Transmitted Infections. 2010;87(2):165-73.
102. Gregson S, Zhuwau T, Ndlovu J, Nyamukapa CA. Methods to reduce social desirability bias in sex surveys in low-development settings - Experience in Zimbabwe. Sexually Transmitted Diseases. 2002;29(10):568-75.

103. Langhaug LF, Sherr L, Cowan FM. How to improve the validity of sexual behaviour reporting: systematic review of questionnaire delivery modes in developing countries. Trop Med Int Health. 2010;15(3):362-81. Epub 2010/04/23.
104. Owens L, Johnson T, O'Rourke D. Culture and Item Nonresponse in Health Surveys. In: Cynamon ML, Kulka RA, editors. Seventh Conference on Health Survey Research Methods; Williamsburg, Virginia: Department of Health and Human Services, CDC; 2001.
105. Network CP-EH. Diverse Patients, Disparate Experience: The use of standardized patient satisfaction surveys in assessing the cultural competence of health care organizations. Oakland, California: California Pan-Ethnic Health Network, 2001.
106. Cleland J, Boerma JT, Carael M, Weir SS. Monitoring sexual behaviour in general populations: a synthesis of lessons of the past decade. Sex Transm Infect. 2004;80(suppl_2):ii1-7.
107. Konings E, Bantebya G, Carael M, Bagenda D, Mertens T. Validating population surveys for the measurement of HIV/STD prevention indicators. Aids. 1995;9(4):375-82. Epub 1995/04/01.
108. Plummer ML, Ross DA, Wight D, Changalucha J, Mshana G, Wamoyi J, et al. "A bit more truthful": the validity of adolescent sexual behaviour data collected in rural northern Tanzania using five methods. Sex Transm Infect. 2004;80(suppl_2):ii49-56.
109. Phillips AE, Gomez GB, Boily M-C, Garnett GP. A systematic review and meta-analysis of quantitative interviewing tools to investigate self-reported HIV and STI associated behaviours in low- and middle-income countries. International Journal of Epidemiology. 2010;39(6):1541-55.
110. Egger M, Smith GD, Phillips AN. Meta-analysis: Principles and procedures. BMJ. 1997;315(7121):1533-7.
111. Mensch BS, Hewett PC, Erulkar AS. The reporting of sensitive behavior by adolescents: a methodological experiment in Kenya. Demography. 2003;40(2):247-68. Epub 2003/07/09.
112. Brown JL, Vanable PA, Eriksen MD. Computer-assisted self-interviews: a cost effectiveness analysis. Behavior research methods. 2008;40(1):1-7. Epub 2008/04/17.
113. Freedman DA, Wachter KW. On the Likelihood of Improving the Accuracy of the Census through Statistical Adjustment. Lecture Notes-Monograph Series. 2003;40(ArticleType: research-article / Issue Title: Statistics and Science: A Festschrift for Terry Speed / Full publication date: 2003 / Copyright © 2003 Institute of Mathematical Statistics):197-230.
114. Aanensen DM, Huntley DM, Feil EJ, al-Own F, Spratt BG. EpiCollect: Linking Smartphones to Web Applications for Epidemiology, Ecology and Community Data Collection. PLoS ONE. 2009;4(9).
115. Cowan F. Improving the validity of sexual behaviour measurement: using computer assisted methods. 19th ISSTDR; Quebec, Canada2011.
116. Langhaug LF, Cheung YB, Pascoe S, Hayes R, Cowan FM. Difference in prevalence of common mental disorder as measured using four questionnaire delivery methods among young people in rural Zimbabwe. Journal of affective disorders. 2009;118(1-3):220-3. Epub 2009/03/24.
117. Johnson TP, Cho YI, Holbrook AL, O'Rourke D, Warnecke RB, Chavez N. Cultural variability in the effects of question design features on respondent comprehension of health surveys. Ann Epidemiol. 2006;16(9):661-8. Epub 2006/02/14.
118. Elam G, McMunn A, Nazroo J, Apwonyoke M, Brookes M, Chinouya M, et al. Feasibility study for health surveys among black African people living in England: final report - implications for the Health Survey for England 2003. 2001.
119. Bauer M, Gaskell G. Qualitative Researching with Text, Image and Sound : A Practical Handbook for Social Research.: Sage Publications Ltd; 2000.
120. Bradburn NM, Sudman S, Blair E, Stocking C. Question Threat and Response Bias. The Public Opinion Quarterly. 1978;42(2):221-34.
121. Ramjee G, Weber AE, Morar NS. Recording sexual behavior: Comparison of recall questionnaires with a coital diary. Sexually Transmitted Diseases. 1999;26(7):374-80.
122. Ferguson AG, Morris CN, Kariuki CW. Using diaries to measure parameters of transactional sex: an example from the Trans-Africa highway in Kenya. Culture Health & Sexuality. 2006;8(2):175-85.

123. Hewett PC, Mensch BS, Erulkar AS. Consistency in the reporting of sexual behaviour by adolescent girls in Kenya: a comparison of interviewing methods. Sex Transm Infect. 2004;80(suppl_2):ii43-8.
124. Cronbach L. Coefficient alpha and the internal structure of tests. Psychometrika. 1951;16(3):297-334.
125. Wringe A, Cremin I, Todd J, McGrath N, Kasamba I, Herbst K, et al. Comparative assessment of the quality of age-at-event reporting in three HIV cohort studies in sub-Saharan Africa. Sexually Transmitted Infections. 2009;85(Suppl 1):i56-i63.
126. Dunne MP, Martin NG, Bailey JM, Heath AC, Bucholz KK, Madden PA, et al. Participation bias in a sexuality survey: psychological and behavioural characteristics of responders and non-responders. Int J Epidemiol. 1997;26(4):844-54. Epub 1997/08/01.
127. Ghani AC, Donnelly CA, Garnett GP. Sampling biases and missing data in explorations of sexual partner networks for the spread of sexually transmitted diseases. Statistics in Medicine. 1998;17(18):2079-97.
128. Mason PR, Gregson S, Gwanzura L, Cappuccinelli P, Rapelli P, Fiori PL. Enzyme immunoassay for urogenital trichomoniasis as a marker of unsafe sexual behaviour. Epidemiol Infect. 2001;126(1):103-9.
129. Minnis AM, Steiner MJ, Gallo MF, Warner L, Hobbs MM, van der Straten A, et al. Biomarker Validation of Reports of Recent Sexual Activity: Results of a Randomized Controlled Study in Zimbabwe. American Journal of Epidemiology. 2009;170(7):918-24.
130. Cowan FM, Langhaug LF, Hargrove JW, Jaffar S, Mhuriyengwe L, Swarthout TD, et al. Is sexual contact with sex workers important in driving the HIV epidemic among men in rural Zimbabwe? Jaids-Journal of Acquired Immune Deficiency Syndromes. 2005;40(3):371-6.
131. Lafort Y, Geelhoed D, Cumba L, Lazaro CD, Delva W, Luchters S, et al. Reproductive health services for populations at high risk of HIV: Performance of a night clinic in Tete province, Mozambique. BMC Health Serv Res. 2010;10:144. Epub 2010/05/29.
132. MEASURE, NAC, MHCW, CDC/Zimbabwe. AIDS in Africa During the Nineties: Zimbabwe. 2002.
133. Zimbabwe Demographic and Health Survey 2005-06. Calverton, Maryland: 2007.
134. Mahomva A, Greby S, Dube S, Mugurungi O, Hargrove J, Rosen D, et al. HIV prevalence and trends from data in Zimbabwe, 1997–2004. Sexually Transmitted Infections. 2006;82(suppl 1):i42-i7.
135. Gregson S, Mason PR, Garnett GP, Zhuwau T, Nyamukapa CA, Anderson RM, et al. A rural HIV epidemic in Zimbabwe? Findings from a population-based survey. 2001. p. 189-96.
136. Lopman BA, Nyamukapa C, Hallett TB, Mushati P, Spark-du Preez N, Kurwa F, et al. Role of widows in the heterosexual transmission of HIV in Manicaland, Zimbabwe, 1998-2003. Sexually Transmitted Infections. 2009;85:I41-I8.
137. Lopman B, Lewis J, Nyamukapa C, Mushati P, Chandiwana S, Gregson S, et al. HIV incidence and poverty in Manicaland, Zimbabwe: is HIV becoming a disease of the poor? Aids. 2007;21 Suppl 7:S57-66.
138. Weir SS, Wilson D, Smith PJ, Schoenbach VJ, Thomas JC, Lamptey PR, et al. Working paper (WP-03-63): Assessment of a Capture-Recapture Method for Estimating the Size of the Female Sex Worker Population in Bulawayo, Zimbabwe. MEASURE Evaluation. 2003.