Final Report

Size Estimation and Engagement in Services Among Female Sex Workers in the Harare, Bulawayo, and Mashonaland Central Provinces of Zimbabwe

Submittted on: December 20, 2017

Submitted to:
Amaka Nwankwo-Igomu, Strategic Information Branch Chief
U.S. Centers for Disease Control and Prevention (CDC) Zimbabwe
38 Samora Machel, Nestle House,
2nd Floor | Harare, Zimbabwe
E-mail: yxu7@cdc.gov

Submitted by:
RTI International
ZimHISP Project Office
Ministry of Health and Child Care
Office Number 1-95, Kaguvi Building
Harare, Zimbabwe
E-mail: hchidawanyika@zimhisp.rti.org or rsembajwe@rti.org

Table of Contents

List of Figures

List of Tables

Acronyms

ART	Antiretroviral therapy
BMGF	Bill and Melinda Gates Foundation
CASI	Computer assisted survey instrument
CD4	CD4 T lymphocyte
CeSHHAR	Centre for Sexual Health and HIV/AIDS Research
CI	Confidence interval
DREAMS	Determined, Resilient, Empowered, AIDS-free, Mentored and Safe initiative
EDTA	Ethylenediaminetetraacetic acid
FSW	Female sex worker
GBV	Gender-based violence
HCP	Health care provider
HIV	Human immunodeficiency virus
IPV	Intimate partner violence
LSHTM	London School of Hygiene and Tropical Medicine
MeSH	Measurement and Surveillance of HIV Epidemics Consortium
NAC	National AIDS Council
NICD	National Institute for Communicable Diseases
PCR	polymerase chain reaction
PHQ-9	Patient Health Questionnaire-9
PMTCT	Prevention of mother-to-child transmission
PrEP	preexposure prophylaxis
PSE	Population size estimate
PSI	Population Services International
QDS	Questionnaire Development System
RCZ	Research Council of Zimbabwe
RDS	Respondent-driven sampling
RPR	Rapid plasma regain
RTI	Research Triangle Institute
SAPPH-IRe	Sisters Antiretroviral therapy Programme for Prevention of HIV—an Integrated Response
Sisters	Sisters with a Voice
SMM	service multiplier method
SOP	Standard operating procedure
SS	Successive sampling
SSQ-8	Eight-item Shona Symptom Questionnaire
STI	Sexually transmitted infection
SW	Sex worker
TPHA	*Treponema pallidum* hemagglutination assay
UNAIDS	Joint United Nations Programme on HIV/AIDS
USAID	U.S. Agency for International Development
UOMM	Uncertainty of measurement method
V-H	Volz-Heckathorn
WHO	World Health Organization
ZNASP II	Zimbabwe National HIV and AIDS Strategic Plan

Executive Summary

Background

Female sex workers (FSWs) bear the burden of the human immunodeficiency virus (HIV) epidemic globally, in Africa and in Zimbabwe. Despite important reductions in incidence and prevalence of HIV in the general population, prevalence and incidence in FSWs remains extremely high. In 2009, National AIDS Council and Ministry of Health and Child Care supported establishment of Sisters with a Voice, a national sex work program for FSWs. The Sisters program is one of few in Africa with national coverage, and currently operates in 36 sites. Over 60,000 women have been seen by the program over the last 8 years. However, without an estimate of the population size, the extent of program coverage is not known.

Population size estimates for key populations are useful for advocacy, informing program planning and implementation, program evaluation, and surveillance purposes. The Joint United Nations Programme on HIV/AIDS (UNAIDS) has recommended a variety of size estimation methods, including literature review, wisdom of the crowds, mapping methods (including census and enumeration), multiplier methods, and population survey methods. There are valid criticisms of all these methods. No method is considered gold standard. All can give estimates that are high or low. Here we report on a size estimation study conducted among FSWs in Harare, Bulawayo, Mazowe, and Shamva.

Size Estimation Study Objectives

The objectives of the study are to:

- estimate the size of the FSW population in Harare and Bulawayo using both the multiplier method and capture–recapture;
- estimate the size of the FSW population in two outreach sites in Shamva and Mazowe, Mashonaland Central Province, using the census method and capture–recapture;
- analyze survey data to determine HIV seroprevalence and sexually transmitted infection (STI) prevalence; and
- refer all FSWs identified through the respective surveys to FSW-friendly HIV prevention, treatment, and care services.

Methods

Size estimation was undertaken using two methods at each site. In Harare and Bulawayo, where Sister program services had been running for many years, the service (SMM) and the unique object multiplier method (UOMM) (capture–recapture) were used. At both Shamva and Mazowe, size

estimates were conducted using a census and UOMM (capture–recapture). At each site, a respondent-driven sampling (RDS) survey was undertaken to inform size estimates and to provide information on HIV and STI prevalence engagement with the care cascade.

First, at each site, mapping was undertaken to characterize geographical spread and typology of sex workers (SWs). Mapping was used to identify "seeds" for initiation of RDS surveys in each site (20 seeds in Harare, 12 in Bulawayo, 6 in Shamva and Mazowe). Following mapping, unique objects were distributed to all FSWs identified at sites identified as sex work locations during mapping.

Following mapping, RDS surveys were conducted at each site. All participants completed an interviewer-administered questionnaire, had a blood sample taken for HIV testing and syphilis serology and, if HIV infected, a further blood sample was taken to determine CD4 count and HIV viral load. One in three participants was randomly selected to have full screening for STIs. Participants were contacted with their test results.

Results

The team surveyed 1,497 participants in Harare, 808 in Bulawayo, 202 in Shamva, and 200 in Mazowe. HIV prevalence was 54.4% in Harare, 52.2% in Bulawayo, 54.8% in Shamva, and 59.2% in Mazowe. Extensive RDS diagnostic testing was conducted and is reported. Overall, 77.7% of HIV-positive FSWs were aware of their HIV status in Harare, 82.3% in Bulawayo, 68.5% in Shamva, and 91.1% in Mazowe. Among all HIV-positive FSWs, 63.4% in Harare were virally suppressed, as were 69.7%, 63.9%, and 75.7% in Bulawayo, Shamva, and Mazowe, respectively. STI prevalence was high overall. Prevalence of *Neisseria gonorrhea* ranged from 7.6% to 21.5%; of *Chlamydia trachomatis*, 6.4% to 10.1%; of *Trichomonas vaginalis*, 26.6% to 39.4%; and of high-risk oncogenic human papilloma virus (HPV), 37.3% to 50.0%.

The FSW population size for Harare was estimated at 12,863 using SMM [95% CI, 10,657–15,068] and 7,629 using UOMM [95% CI, 6,246–9,013] representing 1.5–2.5% of the adult female population. For Bulawayo, population was estimated at 5,687 using SMM [95% CI, 4,505–6,870] and 8,264 using UOMM [95% CI, 5,301–11,227] representing 3.3–4.8% of the adult female population. Using the census, the Shamva population was estimated at 132, and was estimated at 684 using UOMM [95% CI, 349–1,018], representing 16.3% of the adult female population. Using the census, the population estimate for Mazowe was 180 and 613 using UOMM [95% CI, 339–887], representing 3.6% of the adult female population. Taking the median value of the two estimates for Bulawayo, Shamva, and Mazowe yielded population sizes of 6,976, 408, and 397, respectively. There was some concern about UOMM distribution in Harare, and therefore the UOMM estimate for Harare was not

reliable. Following consultation with key stakeholders, it was agreed to use SMM size estimate for Harare, yielding a population estimate of 12,800, rather than the median value of the SMM and UOMM estimates combined.

Discussion

These are the first recent population size estimates for the FSW population in Zimbabwe. Estimates were conducted using rigorous and preplanned methods, and with surveys of appropriately justified sample size. Ranges of size estimates are wide, but are similar to those in other parts of the region. Communicating uncertainty around the estimates is critical. Deriving estimates is an iterative process, and these estimates will be refined going forward. In the meantime, these have been included within Zimbabwe's HIV estimates 2016 report. HIV prevalence is high and in line with previous estimates from population surveys. STI prevalence is high and has implications for programming going forward.

Recommendations

- Refine estimates using additional data sources as they become available.
- Explore additional analytic approaches, including network and RDS successive sampling analyses.
- Strengthen programs to further improve engagement with prevention and care cascades.

1.0 Background

In the last decade, the landscape of the human immunodeficiency virus (HIV) epidemic in Zimbabwe has changed dramatically. Zimbabwe has made historic gains toward ending the HIV epidemic, with the latest data showing more than 50% reduction in HIV prevalence (from 33% in 1997 to 13.8% in 2015). This reduction reflects how the sustained investments in and increased political leadership for the HIV response, among other factors, are succeeding. Although HIV prevalence has been decreasing overall, however, certain subpopulations—such as the FSW population, among whom HIV incidence and prevalence are much higher than in the general population (Busza et al., 2017; F. M. Cowan et al., 2017; F. M. Cowan et al., 2013; J. R. Hargreaves et al., 2015)—remain at particularly high risk for HIV transmission. Data suggest that FSWs underuse HIV services, including testing, prevention, care, and antiretroviral therapy (ART), and that they are less likely to continue to use services (F. M. Cowan et al., 2013). The Zimbabwe National HIV and AIDS Strategic Plan (ZNASP II) 2011–2015 pointed out that key population groups, such as FSWs, men who have sex with men, long-distance truck drivers, and street children, are among the most marginalized social groups, and thus most likely to experience stigma and discrimination (National AIDS Council, 2011). The situation is compounded by inadequate population estimates or HIV prevalence data for key populations, which in turn compromises HIV programming. In Zimbabwe, HIV prevalence among FSWs is substantially higher than for the general population, estimated at between 51% and 70% depending on geographic location (Busza et al., 2017; F. M. Cowan et al., 2017; F. M. Cowan et al., 2013).

Despite longstanding acknowledgement of their enhanced risk, HIV programs in Africa continue to neglect FSWs (Wojcicki & Malala, 2001; World Health Organization, 2011). In addition, sex work is illegal in countries throughout the region, further complicating service delivery (Egger et al., 2000; Ilse & Loren, 2003). Stigma, marginalization, and human rights abuses have been highlighted as key determinants of reduced access to health care among FSWs in southern Africa (Arnott & Crago, 2009; Busza et al., 2017). Sex work remains criminalized in Zimbabwe, with reports of police extortion, confiscation of condoms, and sexual assault (Busza et al., 2017).

Historically, data on rates of HIV testing among FSWs have been scant. Even when such data are reported, they are suboptimal (e.g., only 4% of FSWs surveyed in Somalia in 2008 had ever been tested (Kriitmaa et al., 2010), and only 38% in the Democratic Republic of Congo in 2005–2006 had been tested (Kayembe et al., 2008)). Barriers to testing among FSWs in Zimbabwe are similar to barriers faced by FSWs in other developing countries: lack of awareness of services, distance to facilities, transportation costs, opportunity costs, time constraints, and fear of a positive result (Gage & Ali, 2005; Maman, Mbwambo, Hogan, Kilonzo, & Sweat, 2001; Mshana et al., 2006). Barriers

unique to FSWs include anxiety about contact with authorities and concern about confidentiality, particularly concern that other FSWs or potential clients may learn their status (Munoz, Adedimeji, & Alawode, 2010).

In response to the increased vulnerability and high HIV prevalence among FSWs, in 2009 Zimbabwe implemented its evidence-driven Zimbabwe National Sex Work Programme, Sisters with a Voice (Sisters), which now offers 36 dedicated FSW clinics nationwide that provide clinical services, health education, and group meetings to support community empowerment, as outlined in the World Health Organization's (WHO's) *Consolidated Guidelines on HIV Prevention, Diagnosis, Treatment, and Care for Key Populations* (WHO, 2014). The Sisters program has seen more than 60,000 women since its inception. Nested within Sisters is a cluster randomized trial of treatment as prevention, the Sisters Antiretroviral therapy Programme for Prevention of HIV—An Integrated Response (SAPPH-IRe) trial, which is registered with the Pan African Trials Registry (PACTR201312000722390) (F. Cowan et al., 2016). This trial provided size estimation data from 14 sites around Zimbabwe which, with data from the study presented here, will be incorporated into a National Size Estimate in mid-2017.

A systematic approach to addressing the needs of FSWs in Zimbabwe is required, including studies to establish population size estimates (PSEs) as well as implementation research to provide more information about the extent to which the population is engaged with prevention and care services. Studies to help identify and address both demand- and supply-side barriers to equitable access and retention in HIV prevention, care, and treatment are also needed. The results of the size estimation studies will be shared (and where appropriate combined with the results of SAPPH-IRe trial) to ensure that a national picture emerges and that the findings foster an enabling environment for high-quality, equitable HIV services for FSWs throughout the country.

The research was conducted by the Centre for Sexual Health and HIV/AIDS Research (CeSHHAR) Zimbabwe (which also conducted the SAPPH-IRe trial). The statistical analysis was undertaken by statisticians who are part of the Bill and Melinda Gates Foundation (BMGF) funded Measurement and Surveillance of HIV Epidemics (MeSH) Consortium at the London School of Hygiene and Tropical Medicine (LSHTM). MeSH will work with CeSHHAR to combine size estimates from this study, with PSEs obtained as part of the SAPPH-IRe trial, to provide a national estimate for Zimbabwe.

2.0 Research Objectives

The research has four objectives:

- **Objective 1.** Estimate the size of the FSW population in Harare and Bulawayo using both the multiplier method and capture–recapture.
- **Objective 2.** Estimate the size of the FSW population in two outreach sites in Shamva and Mazowe, Mashonaland Central Province, using the census method and capture–recapture.
- **Objective 3.** Analyze survey data to determine HIV seroprevalence.
- **Objective 4.** Refer all FSWs identified through the respective surveys to FSW-friendly HIV prevention, treatment, and care services:
  - Field researchers referred HIV-positive survey respondents in Harare and Bulawayo to Population Services International (PSI) for ongoing HIV care or preexposure prophylaxis (PrEP), as appropriate. These services have already been established to provide HIV care to vulnerable populations. In addition, women were referred to the Sisters program for sexual and reproductive health services, as required.
  - In Shamva and Mazowe, we referred FSWs to government health services, where health care providers (HCPs) are being trained to offer FSW-friendly services. Peer educator outreach in Mazowe supports these services as part of the U.S. Agency for International Development's (USAID's) DREAMS (Determined, Resilient, Empowered, AIDS-free, Mentored and Safe) initiative.

The overall goal of these activities is to generate information that HCPs can use to advocate for and plan targeted HIV prevention, care, and treatment services for FSWs in Zimbabwe. Table 1 summarizes the primary and secondary outcomes of our research.

Administrative and contractual processes led to delays in study implementation; therefore, it was not possible to implement Objectives 5 and 6, which related to determining retention in HIV care, as outlined in the original version of the approved protocol.

Table 1. Research Outcomes

Primary Outcome • Size estimate of the FSW population in Harare and Bulawayo • Size estimate of the FSW population in Shamva and Mazowe districts
Secondary Outcome • Weighted HIV prevalence among FSWs in each community • Proportion of HIV-infected FSWs who know their HIV status • Proportion of HIV-negative FSWs who have tested for HIV within the previous 6 months • Proportion of all FSWs who have a viral load greater than 1,000 copies/mL • Proportion of HIV-infected FSWs who have a viral load greater than 1,000 copies/mL • Proportion of HIV-infected FSWs on ART who have a viral load greater than 1,000 copies/mL • Prevalence of other STIs among FSWs in each community • Estimate of engagement in the HIV care cascade in Harare and Bulawayo • Estimate of engagement in the HIV care cascade in Shamva and Mazowe districts • Proportion of those experiencing GBV in the previous 12 months • Proportion of those experiencing problematic alcohol use • Proportion of those experiencing poor mental health

ART = antiretroviral therapy; FSW = female sex worker; GBV = gender-based violence; HIV = human immunodeficiency virus; STI = sexually transmitted infection.

3.0 Methods

3.1 Overview of Research

The CeSHHAR team conducted rapid ethnographic mapping of the spatial and social organization of sex work at each of the four research sites. This was followed by a biobehavioral survey in each site to estimate HIV and STI prevalence, engagement in care, and other representative characteristics of FSWs at each site. which was conducted using respondent-driven sampling (RDS), a form of chain-referral sampling recommended for obtaining representative estimates for key populations that lack a sampling frame. PSEs were then calculated using two methods for each site and information collected during the mapping and survey phases. Each of these activities is described in more detail below.

During mapping, researchers distributed unique objects (a bracelet) to sex workers (SWs), later to be used in population size estimation (described below), and conducted population censuses in the smaller sites, Shamva and Mazowe. The initial recruiters (seeds) were SWs who researchers purposively selected from a range of ages, geographic areas, and sex work typologies (bar-based, street-based, highway-based) identified during rapid ethnographic mapping.

3.2 Size Estimation in Harare and Bulawayo

We used two techniques to estimate population size in each study location: the service multiplier method (SMM) and the unique object multiplier method (UOMM). The detailed methods are described in the section on Size Estimation Methods below.

3.3 Mapping

The CeSHHAR team used mapping to identify sex work locations, determine the location and number of survey sites, and identify seeds, purposively selected participants who initiate the peer-referral survey recruitment process. During the mapping process, we identified and recruited FSWs through interviews with key informants (e.g., health staff, bartenders, other FSWs). Identified FSWs were asked what they know about sites where FSWs congregate or to find clients in the locality and draw up a list of all sex work venues. Key informants were asked to estimate roughly how many FSWs they thought worked at each venue. We gave FSWs identified during the mapping process a small token (a rubber wristband/bracelet) and selected seeds at each survey site.

3.4 Respondent-driven Sampling

RDS is an adaptation of chain referral sampling. Initial "seed" participants are selected to represent a range of characteristics (e.g., diversity in age, location, type of sex work)(James R. Hargreaves et al., 2016). The seeds are given coupons to recruit further participants, who are in turn given coupons, and so on, until sample size is reached. RDS has been shown to reduce sampling bias and improve representativeness of hard-to-reach populations by limiting the number of referrals any one respondent can have (thus creating long recruitment chains more likely to "converge" away from initial seed characteristics), and through the use of specific statistical techniques that weight participants proportionally to their likelihood of inclusion in the sample.

Seed participants were selected according to information collected during the mapping phase. The number of seeds per site was predetermined by the sample size (Harare had 20; Bulawayo had 12). For Mazowe, we identified three locations where sex work was common (Mazowe mine, Glendale, and Mvurwi). We recruited two seeds each for Mazowe mine, Glendale, and Mvurwi, and six seeds for Shamva growth point. When mapping was complete, we cross-tabulated typologies against venue types and geographic areas. Correspondingly, seeds were distributed across geographic areas, typology, venue types, and the age range. We identified SWs who met these characteristics and recruited them as seeds.

Each recruited participant completed an interviewer-administered questionnaire, and an HCP collected a finger-prick blood sample for HIV antibody testing using national testing algorithms and syphilis testing protocols. If a participant was HIV positive, the HCP drew further blood samples for CD4 T lymphocyte (CD4) cell count and viral load testing. One in three participants was randomly selected for genital examination and screening for sexually transmitted infection (STI). All laboratory results were provided to participants within 2 weeks.

Following completion of survey procedures, a field team member issued each participant two coupons to use for referring two peers ("recruits"). Each recruit, in turn, was given two coupons to refer another two peers. Participants received $5 for completing the questionnaire and testing for HIV. Participants received an additional $2 for each recruit they referred (up to a maximum of two). We issued coupons until sample size was reached, which required up to seven "waves" of recruitment in Harare and six waves in the other sites.

A detailed protocol is available in Appendix 1 and standard operating procedure (SOP) for RDS are available in Appendix 2. In brief, we screened recruits for eligibility, asked them to provide written informed consent, had them complete an interviewer-administered questionnaire (using a computer-assisted survey instrument [CASI]), and then collected a finger-prick blood sample for rapid HIV and syphilis testing. Those who had a positive HIV result had further blood drawn to test for HIV viral load and CD4 count. One in three participants was randomly selected to undergo genital examination and STI testing. On completion of survey procedures, we issued each participant two recruitment coupons to give to their peers.

Inclusion criteria were as follows:

- Age 18 or older
- Currently working as an SW (has exchanged sex for money in the past 30 days)
- Living or working in the study site

Exclusion criteria included:

- being under 18 years of age;
- having already participated in the survey;
- visiting the study site temporarily (for less than 1 month); and
- not currently working as an SW (verification questions were used to prevent fraudulent participation, such as how sex work is organized in the area and the cost of different sex acts).

The questionnaire data were collected anonymously and included sociodemographic, economic, and sexual behavior; psychological health; physical health; past history of STIs; sexual and social networks; social capital; use of services, including HIV testing, ART, prevention of mother-to-child transmission (PMTCT), and family planning; history of gender-based violence (GBV); and psychological health. We created the questionnaire in English, and then translated it into Shona and Ndebele, the local languages. (To read the English-language questionnaire, see Appendix 3.) We

collected the questionnaire data directly in a computer-assisted survey instrument (Questionnaire Development System [QDS], Nova Research Company, Silver Spring, MD, USA). We ran two training workshops to train research staff to undertake RDS and use the RDS database as well as administer the CASI questionnaire. Questionnaires were backed up daily to cloud storage.

3.5 Statistical Analysis

We calculated descriptive statistics for the sociodemographic and sex work characteristics, as well as study outcomes of women at each site, by using the RDS weighting procedure described below to account for sampling design. One-third of women were randomly allocated to an offer of STI examination and testing: We compared the characteristics of those women who did and did not accept this offer to assess possible participation bias.

We conducted RDS diagnostic procedures to investigate the performance of the sampling and to interpret how deviations from assumptions might have affected the estimates, including the population size estimates. These procedures are described in detail in the sections that follow.

3.6 RDS-II

We weighted our analyses of the RDS surveys, including HIV and STI prevalence, by using RDS-II, the Volz-Heckathorn (V-H) estimator. The estimator weights participants' responses by the inverse of their reported personal network size (Volz & Heckathorn, 2008), which we determined by asking women how many other FSWs they knew who resided at the site, were over 18 years of age, who they had seen in the past month, and to whom they would consider giving a coupon to participate in the study. *Knowing* was defined as "you know their name and they know yours." Assuming that these social ties were reciprocated, the number of SWs the participant reported as knowing was the same as the number of women who could have given the participant a coupon. The RDS-II estimator is based on a "random walk" model of the sampling process, under which the sampling probability of each respondent (except the seeds who were dropped from the estimation, because they were purposively sampled) was proportional to the inverse of the number of women who could have given the participant a coupon. This estimator has been recommended over earlier RDS estimators (K.J. Gile & Handcock, 2010).

Following RDS guidance, we conducted a set of diagnostic procedures to assess whether the RDS sampling had proceeded as described above (Krista J. Gile, Johnston, & Salganik, 2015). We conducted the diagnostics for HIV prevalence and care cascade variables, as well as the variables used in multiplier method size estimation, described below. We first examined diagrams of recruitment, or "recruitment-trees." We then assessed whether the estimates appeared to have

stabilized before the end of recruitment (convergence) by plotting the estimate by sample wave (RDS-II weighted cumulative estimate). We calculated "recruitment homophily," which is the tendency for respondents to recruit others like themselves, and examined the mean network size among those who did and did not have the outcome. We used these diagnostics to understand the extent to which our estimates might have been biased too high or too low, and the effect this bias, in turn, might have had on our population size estimates (Chabata, 2015), although this bias ultimately cannot be known with certainty.

We used the RDS package (Handcock, Fellows, & Gile, 2016; R Core Team, 2015) for R statistical software version 3.3.2 (R Core Team, 2015).

3.7 Size Estimation Methods

We calculated estimates of the population size and their 95% confidence intervals (CIs) using two methods at each site:

- **Harare:** SMM and UOMM
- **Bulawayo:** SMM and UOMM (two rounds)
- **Shamva:** Census and UOMM (two rounds)
- **Mazowe:** Census and UOMM (two rounds)

3.8 Census Method

Following detailed geographic mapping of the communities in Shamva and Mazowe, where hotspots and geographic locations were identified where sex is bought and sold, a census was conducted to count the actual number of FSWs working at each location. The census was conducted on either Friday or Saturday night using a team of six surveyors who went from hotspot to hotspot. The census in each site was completed over 2–3 hours during one evening to minimize risk of double counting.

3.9 Unique Object and Service Multiplier Methods

Multiplier methods use two pieces of information. The first is a count of an object distributed among the population (UOMM), or a count of unique members of the target population who attended some service or program in a given time period (SMM). Second, representative estimates of the proportion of target population members who either received the object or attended the service in the time period are obtained. This information is combined as below to obtain a population size estimate:

$$PSE = M/P \qquad \text{Equation 1}$$

where the *PSE* is the population size estimate, *M* is the count of the target population, and *P* is the proportion estimated in the representative survey.

For the UOMM, conducted in all sites, we handed out a set number (*M*) of unique objects (a wristband) to SWs working at that site during mapping. Wristbands were handed to all SWs at locations identified during geographic mapping including bars, truck stops, marketplace, street, etc. Seeds initiating the RDS were also selected from these geographic locations. Due to unforeseen delays, there was a longer time gap between the mapping and RDS survey phases than anticipated, so we distributed a second round of wristbands in all sites except in Harare, where data collection had already begun. Wristbands were color-coded according to round. In the later RDS surveys, we asked women if they had received a wristband and, if so, what color it was, and then used this information to obtain RDS-II weighted proportions of women who had received wristbands at each round for each site (either 8 weeks before the survey or 2 weeks before).

It was possible to conduct the SMM at sites where the Sisters program could provide records of attendance at a clinic providing sexual health services to FSWs in Harare and Bulawayo.

We obtained *M* by counting the number of unique IDs listed in the Sisters clinic visit database at the corresponding site from the midpoint date of the survey back 6 months. We adjusted this number down by the percentage of likely duplicate IDs—that is, the number of IDs issued in error to a woman who had already been allocated an ID, identified via a matching algorithm.

We estimated *P* as the RDS-II weighted proportion of women in the survey who responded yes to the question: "In the past 6 months have you attended the Sisters with a Voice clinic?"

For both UOMM and the SMM, we used Equation 1 to calculate the size estimate for each method, and in the case of UOMM, each wristband distribution round. We calculated 95% confidence intervals for each *PSE* using the Delta method to combine the variance in *M* and *P*, as below (Chabata, 2015; Johnston et al., 2013):

$$Var\left(\frac{M}{P}\right) \approx \frac{se(P)^2 \mu_m^2}{\mu_P^4} + \frac{\mu_M}{\mu_P^2} \qquad \text{Equation 2}$$

where $\mu_M$is the number of individual members of the target population on the clinic register or the number of wristbands distributed, given that, μ_P is the estimate for the proportion we wish to estimate and s*e(P)*^{2} is the squared standard error of *P*. The s*e(P)* was obtained using bootstrap procedures implemented in the RDS package for RDS-II weighting. The 95% confidence interval (CI) around the *PSE* was then obtained by taking the square root of *var(M/P),* multiplying by 1.96 (assuming an approximately normal distribution) and subtracting/adding to the *PSE*.

We examined the RDS diagnostics to comment on whether the *PSE*s we calculated might have been over- or underestimated. A key assumption of the multiplier method for population size estimation is that *M* and the estimate of *P* are independent of each other. If, for example, clinic attenders were more likely to be RDS survey participants than other FSWs, this could lead to an overestimation of clinic attendance, and a corresponding underestimation of the population size (according to Equation 1). The same could be true for wristband receipt. High recruitment homophily and a large difference in network size by program attendance or wristband receipt could also make convergence slower. We examined these recruitment dynamics and interpreted them in light of the population sizes we estimated, using the SMM and the UOMM.

3.10 Laboratory Procedures

After completing the questionnaire, each participant had a finger-prick blood sample taken for rapid HIV testing, and pre- and post-HIV counselling was offered. Samples were tested according to the Zimbabwe National HIV testing algorithm in series (see Standard Operating Procedures Appendix 2). The syphilis sample was tested using Chembio DPP Syphilis Screen & Confirm Assay (Chembio Diagnostic Systems, Medford, NY, USA) and results given to participants. All participants testing syphilis positive were asked to provide an additional blood sample to run a Confirm POC test, a near-patient assay that tests for both rapid plasma reagin (RPR) and *Treponema pallidum* hemagglutination assay (TPHA). All HIV-positive women had finger-prick blood drawn for CD4 count testing and an ethylenediaminetetraacetic acid (EDTA) sample for HIV viral load testing. Viral load and CD4 count testing were conducted at the Flow Cytometry Laboratory. All samples were sent to the laboratory within 48 hours of collection. Viral load was tested using Xpert HIV-1 Viral Load (Cepheid, Sunnyvale, CA, USA) performed on GeneXpert Instrument Systems (Cepheid) (Drain & Garrett, 2015; Kuhn, 2015; Mor et al., 2015; Vojnov & Scott, 2015).

STI testing for *Neisseria gonorrhea*, *Chlamydia trachomatis*, *Trichomonas vaginalis*, oncogenic human papilloma virus (HPV), and genital ulcer organisms (herpes simplex virus type 2 [HSV-2], *Hemophilus ducreyi*, and *Treponema pallidum*) was conducted on one of three randomly selected participants. We asked these participants about symptoms of STIs, and then they underwent a genital examination. Signs of STI were recorded. All women had a vaginal swab collected for *T. vaginalis* using Xpert TV (Cepheid) plus cervical swabs collected to test for *N. gonorrhea* and *C. trachomatis* using Xpert CT/NG (Cepheid) (Mungati et al., 2015). Cervical samples of all women were collected using a cervix brush and placed in PreservCyt 20-mL-vial solution (Hologic, Marlborough, MA, USA) for HPV. All STI samples were transported to the Flow Cytometry Laboratory within 48 hours at 4^{o}C. All women with genital ulceration found on genital examination had a swab of the

ulcer collected for multiplex polymerase chain reaction (PCR) testing by the National Institute for Communicable Diseases (NICD) in Pretoria, South Africa. Specimens are being stored at −80°C in the Flow Cytometry Laboratory, and we are currently seeking approval from the Research Council of Zimbabwe to transport them to South Africa.

3.11 Institutional Review Board Approval

Institutional review board (IRB) approval for the study was given by the Medical Research Council of Zimbabwe, the Research Council of Zimbabwe (RCZ), University College London Ethics Committee, LSHTM, and RTI.

4.0 Results

4.1 Mapping

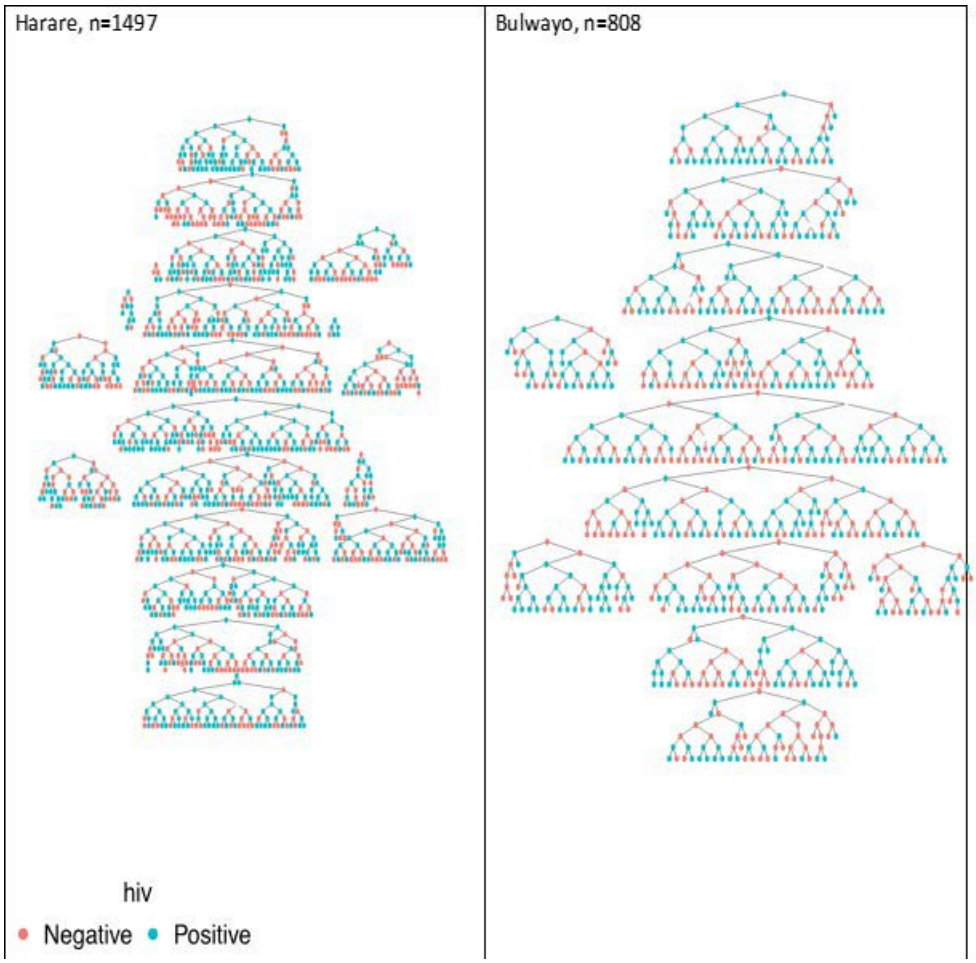
Detailed but anonymized reports of the mapping exercise are included in the appendix (names and location of sex work venues have been disguised). In summary, SW networks were sufficiently deep and wide to allow an RDS approach. We identified the venues and types of SWs to include in selection of seeds. We identified areas in which SWs operate, including the busiest days as well as key people and other services available for SWs in the different sites. Seeds from the different locations and of varying age groups, including young women who sell sex, were selected. These women ranged in age from 18 to 68 years; they covered all types of sex work identified and all geographic locations.

4.2 RDS Survey

4.2.1 Recruitment

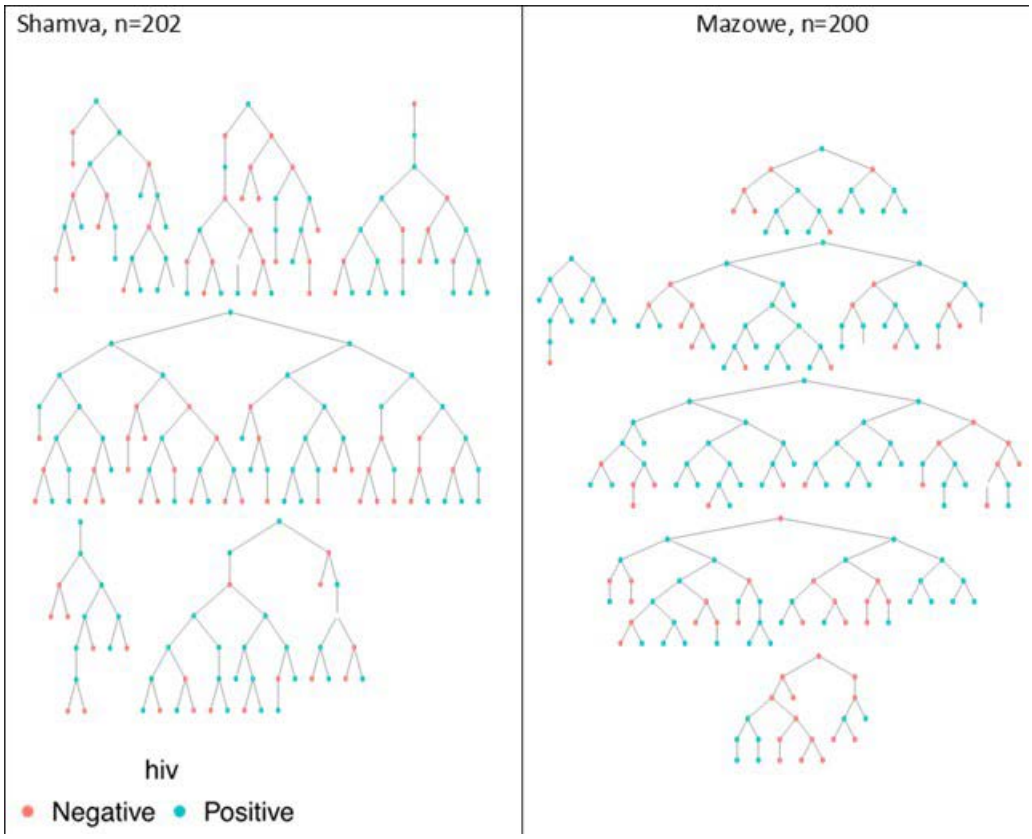
The team surveyed 1,497 in Harare (17 March 2017 to 21 April 2017), 808 in Bulawayo (24 April 2017 to 25 May 2017), 202 in Shamva (24 April 2017 to 10 May 2017), and 200 in Mazowe (8 May 2017 to 19 May 2017). As outlined in the protocol, in Bulawayo, Shamva, and Mazowe, there were up to six waves of recruitment; in Harare, there were seven waves. All seeds were productive, as shown in Figures 1 and 2.

Figure 1. Chains of Recruitment in Harare and Bulawayo by HIV Status



HIV = human immunodeficiency virus.

Figure 2. Chains of Recruitment in Shamva and Mazowe by HIV Status



HIV = human immunodeficiency virus.

5.0 RDS Diagnostics

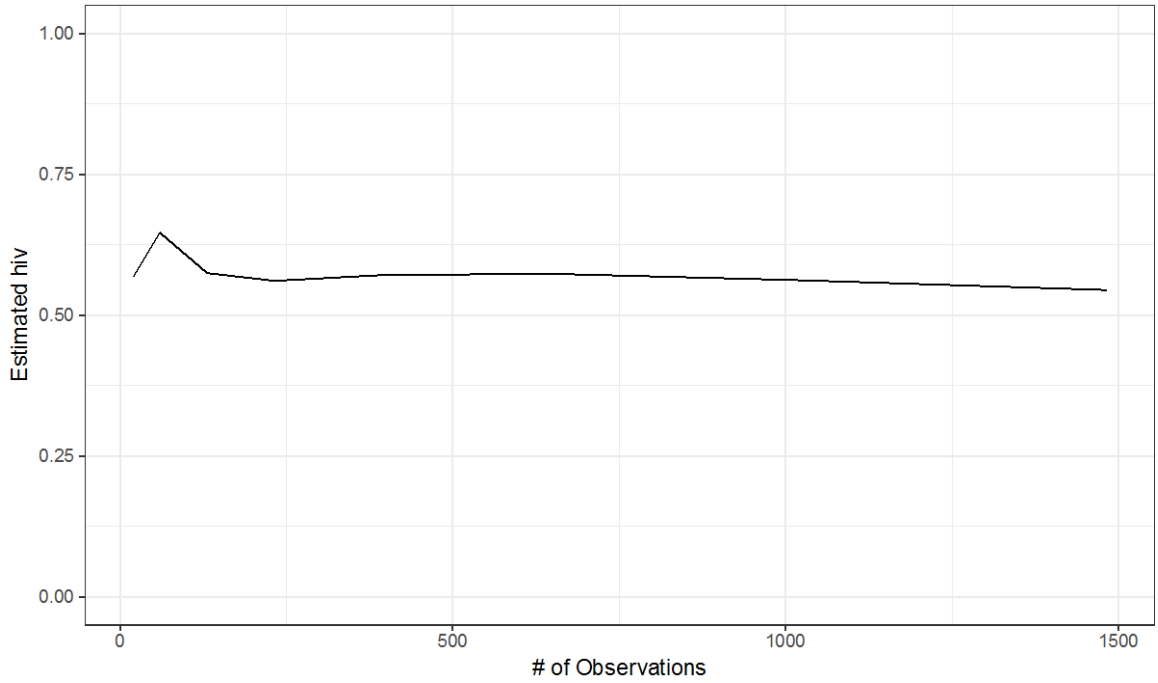
The charts that follow summarize the RDS diagnostics we conducted to understand the PSEs obtained using multiplier methods, drawing on convergence plots and the table on recruitment homophily and network size.

5.1 Convergence of Main Outcome Estimates

5.1.1 HIV Prevalence

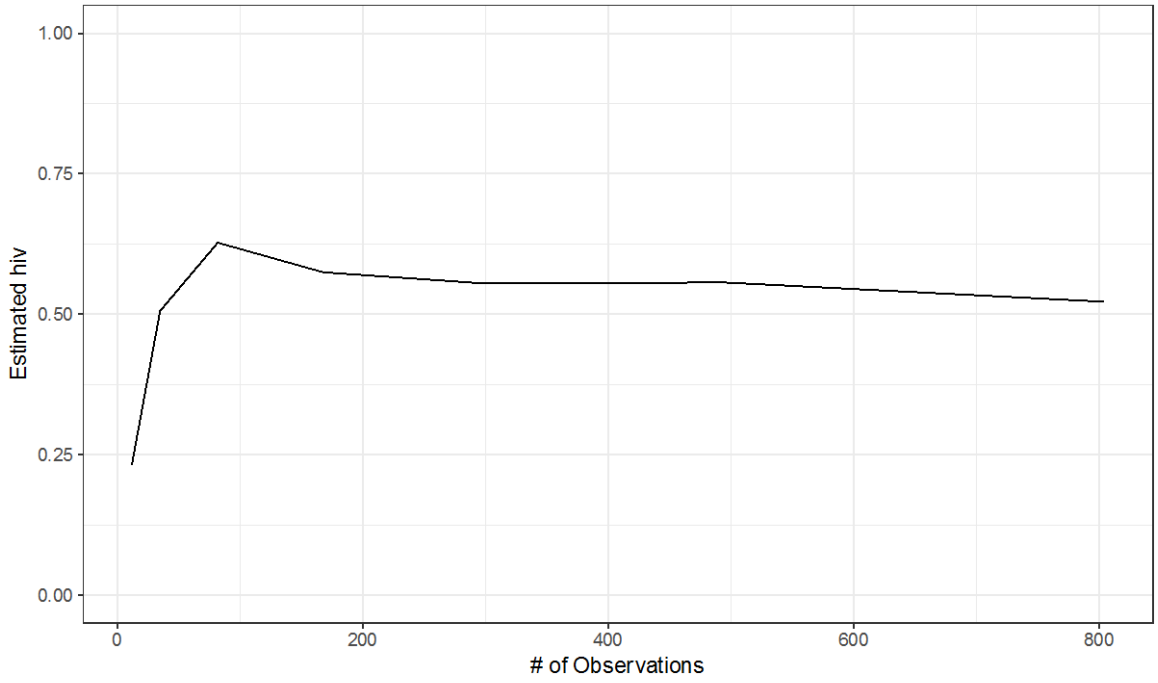
We graphically examined the convergence of the HIV prevalence estimate over sample accumulation to assess whether the estimates appeared to have stabilized and were independent of initial seed characteristics (Figures 3 through 6). While graphical examination does not give an objective and definitive answer for whether an estimate has converged and is independent of seed characteristics, a simple test for convergence is not recommended (Krista J. Gile et al., 2015). For each site, we graphed how HIV prevalence changed with each recruited wave of the sample.

Figure 3. Harare: Convergence of Cumulative Weighted HIV Prevalence Estimates over Sample Waves



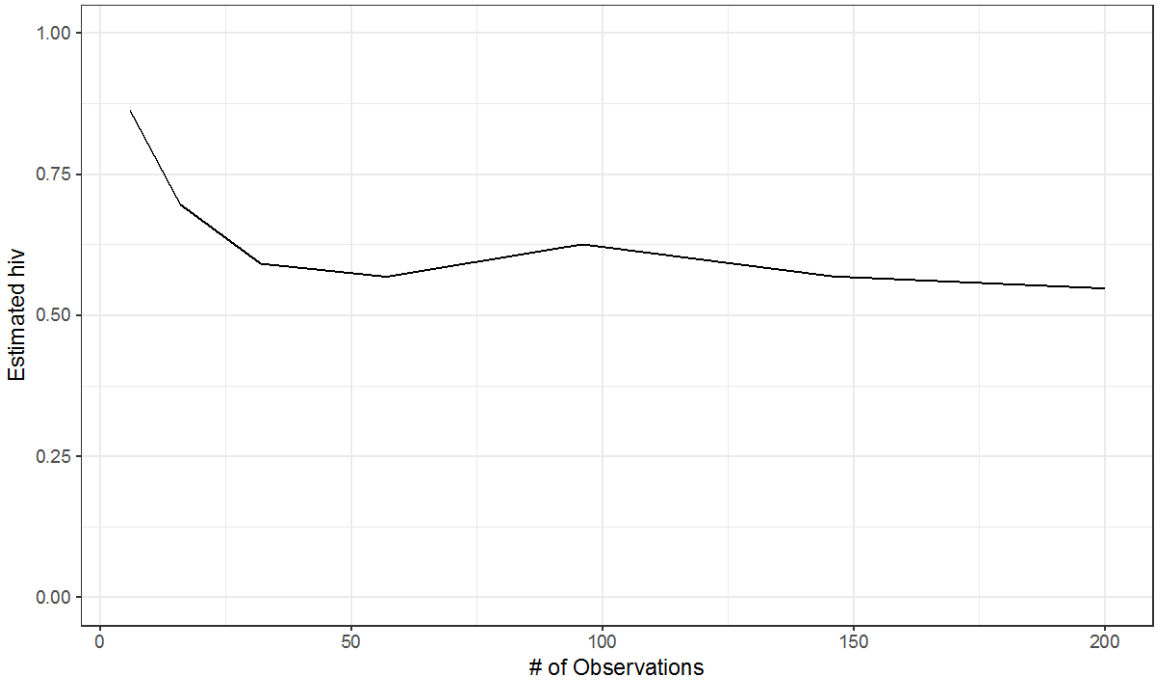
HIV = human immunodeficiency virus.

Figure 4. Bulawayo: Convergence of Cumulative Weighted HIV Prevalence Estimate over Sample Waves



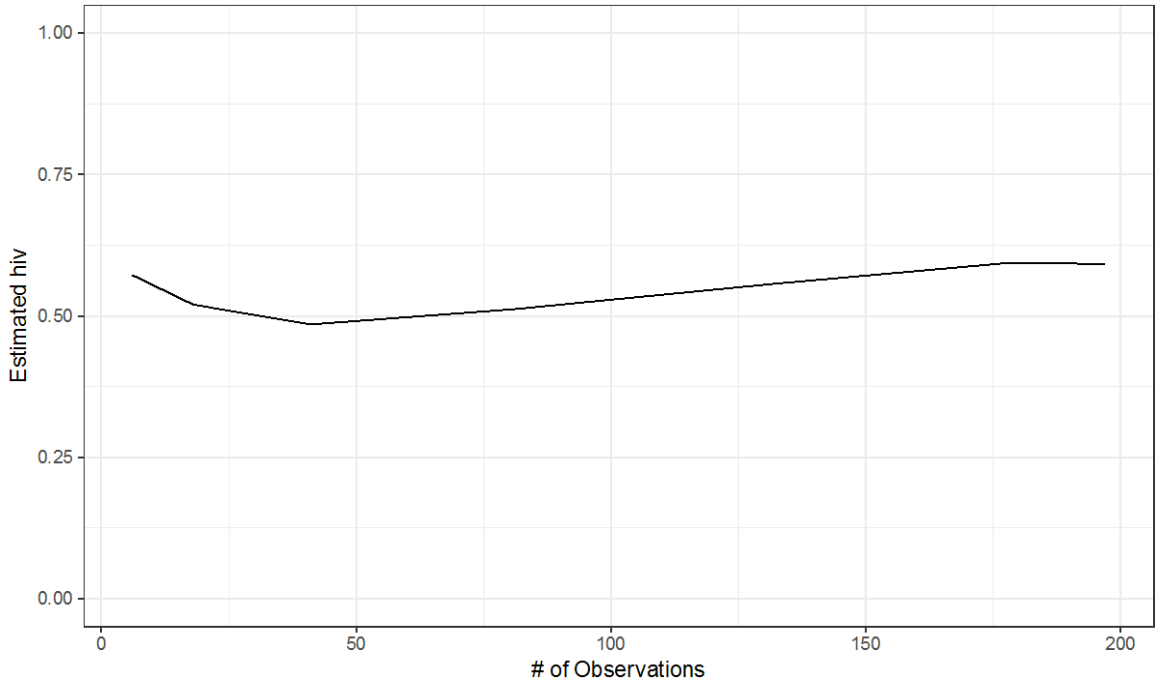
HIV = human immunodeficiency virus.

Figure 5. Shamva: Convergence of Cumulative Weighted HIV Prevalence Estimate over Sample Waves



HIV = human immunodeficiency virus.

Figure 6. Mazowe: Convergence of Cumulative Weighted HIV Prevalence Estimate over Sample Waves



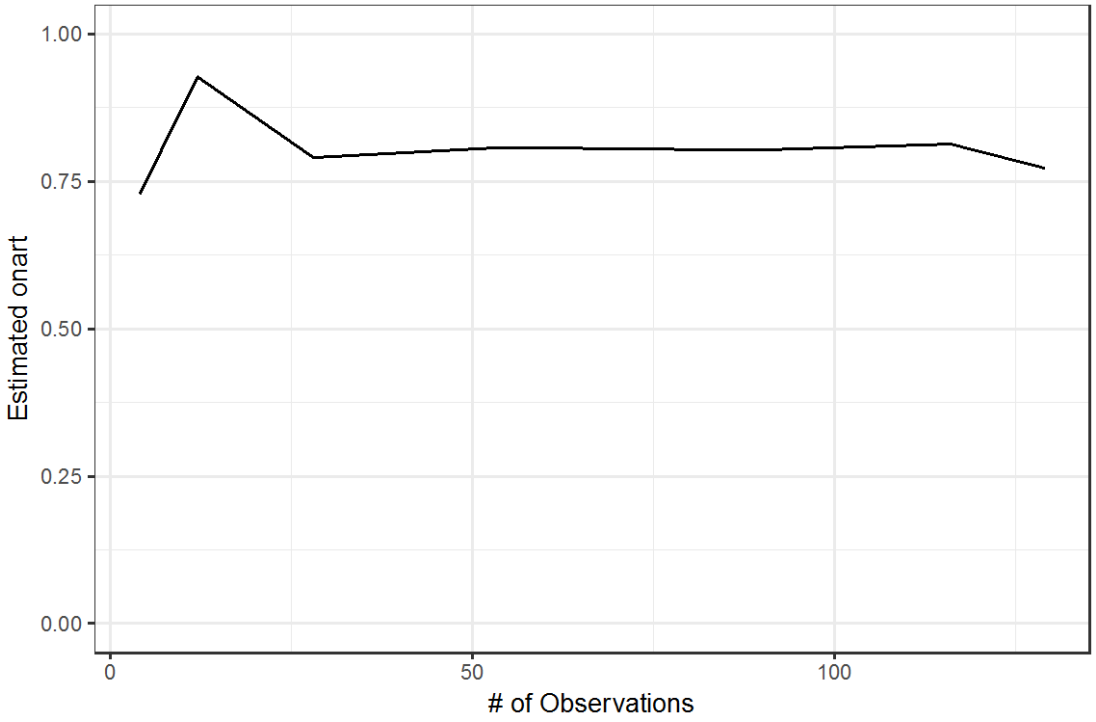
HIV = human immunodeficiency virus.

5.1.2 Care Cascade Variables

For all sites, the estimate of the proportion of HIV-positive women aware of their status converged well, as did the estimate of the proportion of women on ART except for Mazowe, for which the value might have been slightly overestimated (see Figures 7 and 8). The proportion of HIV-positive women

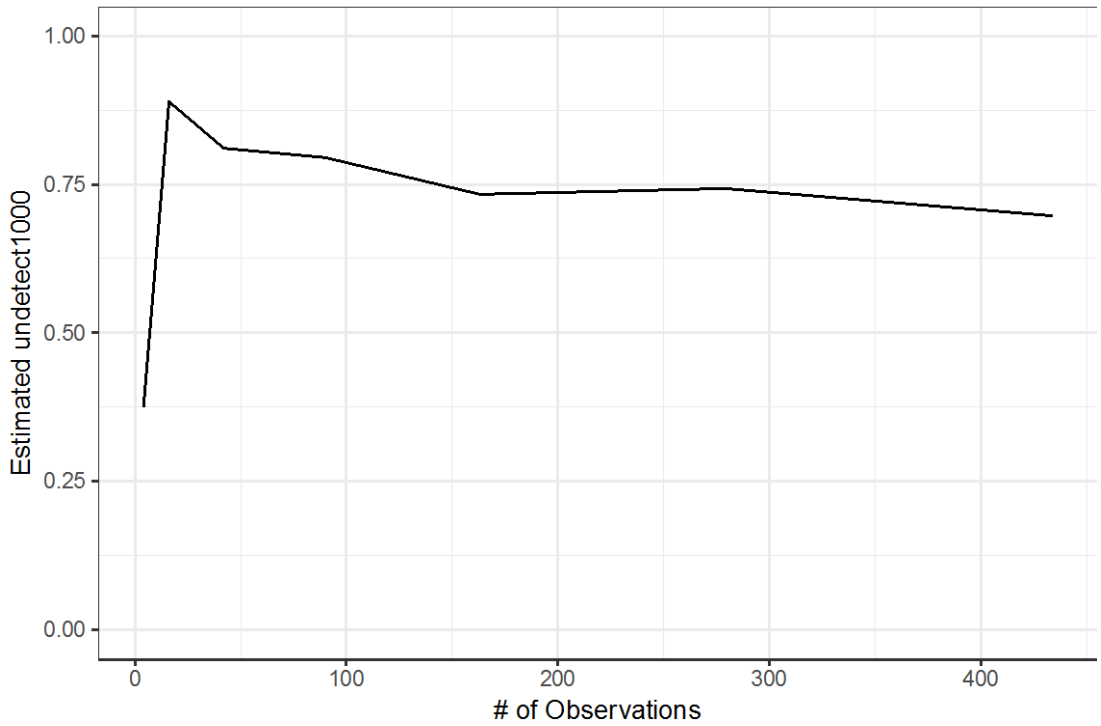
who had an unsuppressed viral load converged reasonably in all sites except possibly Bulawayo, where it might have been overestimated (see Figure 7).

Figure 7. Mazowe: Convergence of Cumulative Weighted Prevalence of Being on ART among Those HIV-Positive Women Estimate over Sample Waves



ART = antiretroviral therapy.

Figure 8. Bulawayo: Convergence of Cumulative Weighted Prevalence of Suppressed Viral Load among Those HIV-Positive Women over Sample Waves



5.2 Interpretation of Convergence of HIV Prevalence Estimates

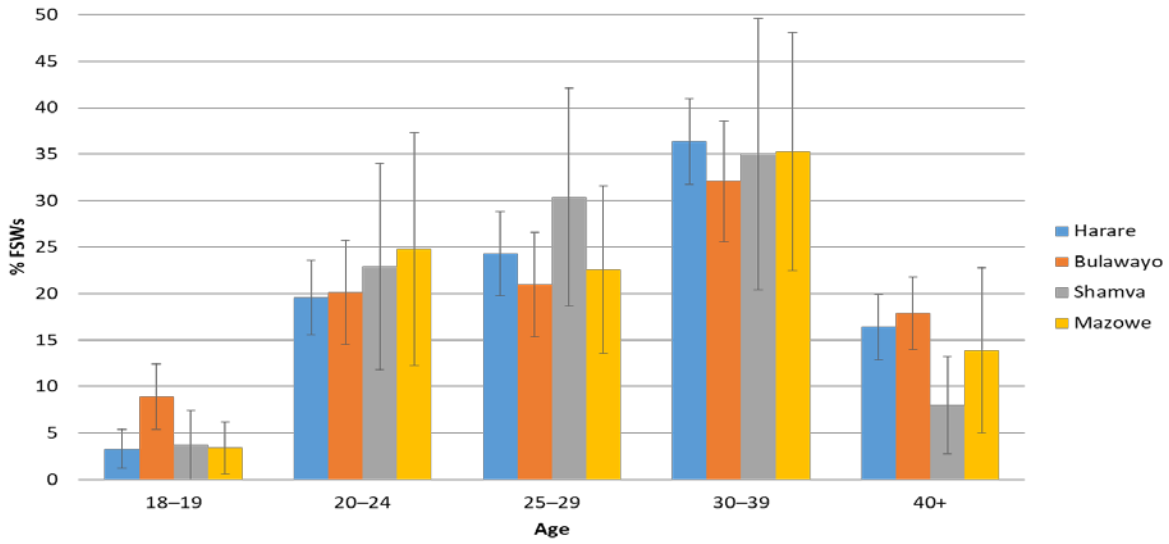
Convergence of the estimate for HIV prevalence was reasonable in Harare, Bulawayo, and Shamva. In Mazowe, the estimate might have risen further had sampling continued, so the value might be slightly underestimated. Recruitment homophily—the tendency for participants to recruit those of the same HIV status as themselves—was very low in Harare and Shamva, at 1.04 and 1.02, respectively (with 1 indicating the equivalent of random recruitment by HIV status) and somewhat higher in Bulawayo (1.10) and Mazowe (1.25). That recruitment homophily was higher in Mazowe, which might account for the poorer convergence.

In summary, the estimates of the outcomes appeared to have converged reasonably well, implying good representativeness. Overall, we judged that RDS had worked well across the four sites.

5.3 Sociodemographic Characteristics of Participants

The age distribution of respondents was similar across all four sites, with the majority between 30 and 39 years of age and the youngest participants between 18 and 19 years of age (see Figure 9). Bulawayo had the highest proportion of women between 18 and 19 years of age with 8.9% (95% CI, 5.4–12.4), followed by Shamva with 3.7% (95% CI, 0.0–9.1), then Mazowe with 3.4% (95% CI, 0.6–6.2), and finally Harare with 3.3% (95% CI, 1.2–5.4).

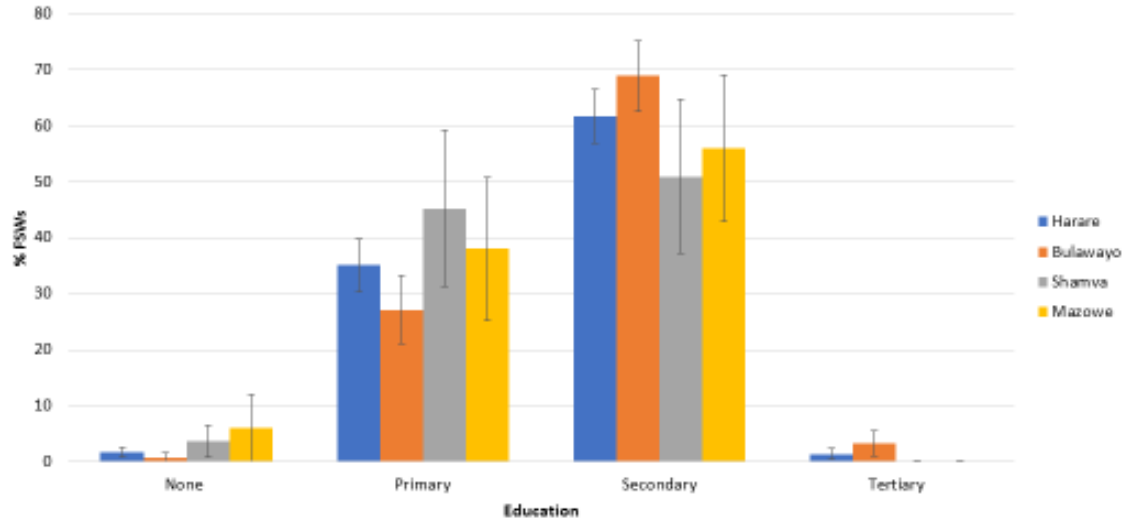
Figure 9. Age and Distribution of FSWs by Site



FSW = female sex worker.

More than half of respondents across all sites had attained up to secondary-level education, between 26.1% and 45.2% had attained primary-level education, and less than 3% across all sites had no formal education at all (see Figure 10). Few women had attained tertiary-level education; of those who had, the highest proportion—2.7% (95% CI, 1.1–3.3)—was reported in Bulawayo.

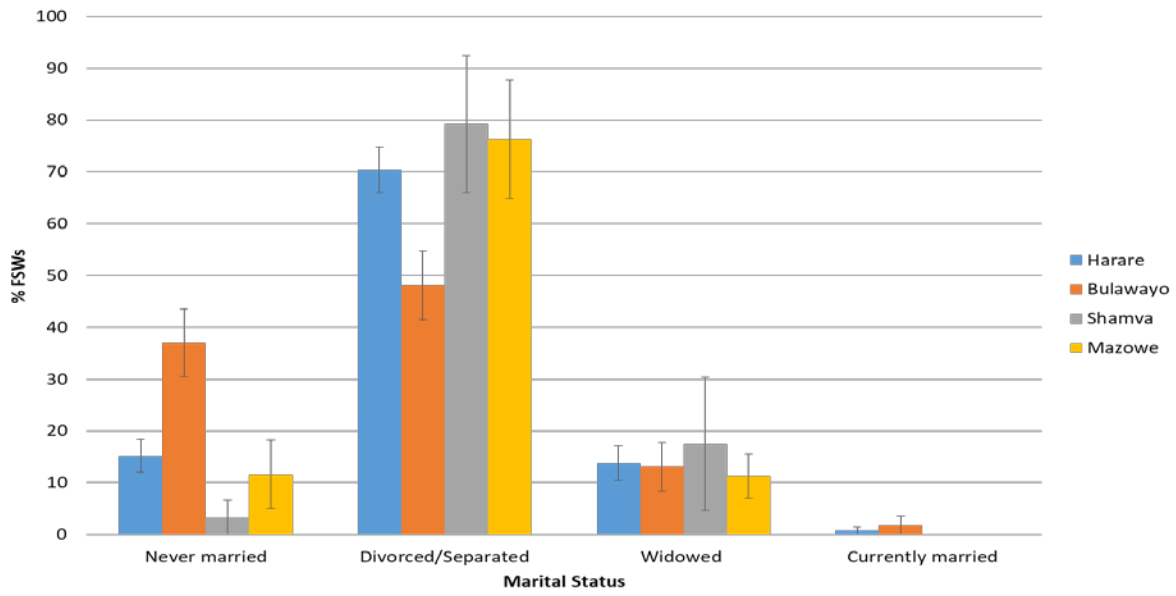
Figure 10. Level of Education among FSWs by Site



FSW = female sex worker.

Marital status varied by site, as well (see Figure 11), with the majority of women divorced, separated, or widowed.

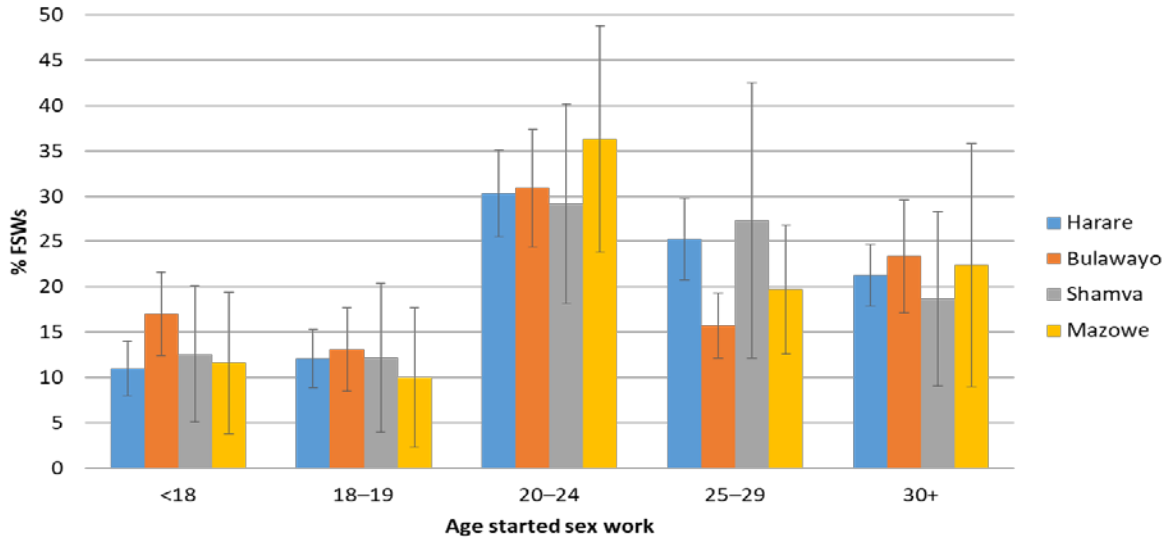
Figure 11. Marital Status among FSWs by Site



The age of women starting sex work showed a similar pattern across all four sites (Figure 12). Most women reported that they had started selling sex when they were between 20 and 24 years of age. Women who reported selling sex before they were 18 years of age ranged between 11.4% and 17%. Bulawayo had the highest proportion at 17% (95% CI, 12.4–21.5), followed by Shamva at 12.6% (95% CI, 5.1–20.1), Mazowe at 11.6% (95% CI, 3.8–19.4), and Harare at 11.4% (95% CI, 8.0–14.0). This

finding is consistent with previous surveys that reported participants starting sex work at a younger age than the actual proportion seen in surveys or attending sex work–specific programs.

Figure 12. Age of Women at the Start of Sex Work by Site



FSW = female sex worker.

Most women reported having had 1–5 clients in the past week. The proportion was highest in Bulawayo, with 48.5% of women reporting having had 1–5 clients per week; 43.8% reported the same in Mazowe, 37.8% in Shamva, and 32.3% in Harare. In Mazowe, 28.3% of women reported having had more than 16 clients in the previous week, representing the highest FSW-to-client ratio. Table 2 shows the number of clients FSWs had had in the previous week.

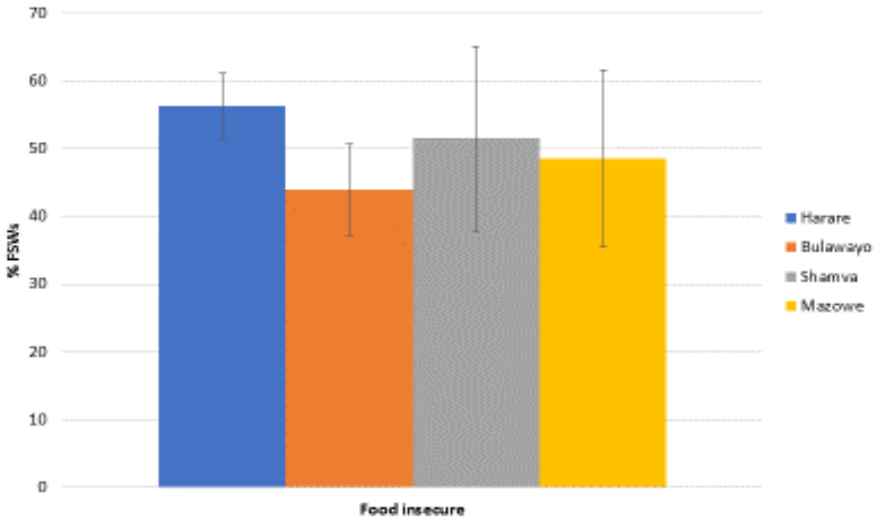
Table 2. Number of Clients in the Previous Week by Site

		Harare, *n* = 1,497				Bulawayo, *n* = 808				Shamva, *n* = 202				Mazowe, *n* = 200			
		No.	RDS-II Weighted, %	95% CI for RDS-II Weighted Proportion		No.	RDS-II Weighted, %	95% CI for RDS-II Weighted Proportion		No.	RDS-II Weighted, %	95% CI for RDS-II Weighted Proportion		No.	RDS-II Weighted, %	95% CI for RDS-II Weighted Proportion	
No. of clients in the previous week	0	49	3.6	1.4	5.8	38	6.3	1.6	11.0	11	8.9	0.1	17.7	14	7.6	1.0	14.3
	1–5	406	32.3	27.5	37.1	368	48.5	41.8	55.2	73	37.8	25.2	50.4	82	43.8	30.7	56.9
	6–10	422	28.8	24.2	33.5	214	24.5	19.0	30.0	45	21.8	8.4	35.3	32	13.0	5.5	20.4
	11–15	209	12.4	9.3	15.5	78	7.6	5.3	10.0	30	13.0	5.8	20.2	19	7.3	2.7	11.8
	16+	411	22.9	19.2	26.6	110	13.0	8.4	17.6	43	18.5	7.9	29.1	53	28.3	16.0	40.5

CI = confidence interval; RDS-II = respondent-driven sampling.

Reported food insecurity was high across all sites, as measured by three questions that assessed hunger and food availability. Harare had the highest proportion of women who reported being food insecure, at 56.3% (95% CI, 51.5–61.1), followed by Shamva at 51.5% (95% CI, 37.9–65.1), Mazowe at 48.6 (95% CI, 35.5–61.7), and Bulawayo at 44.0% (95% CI, 37.3–50.7). Figure 13 shows food insecurity among FSWs by site surveyed.

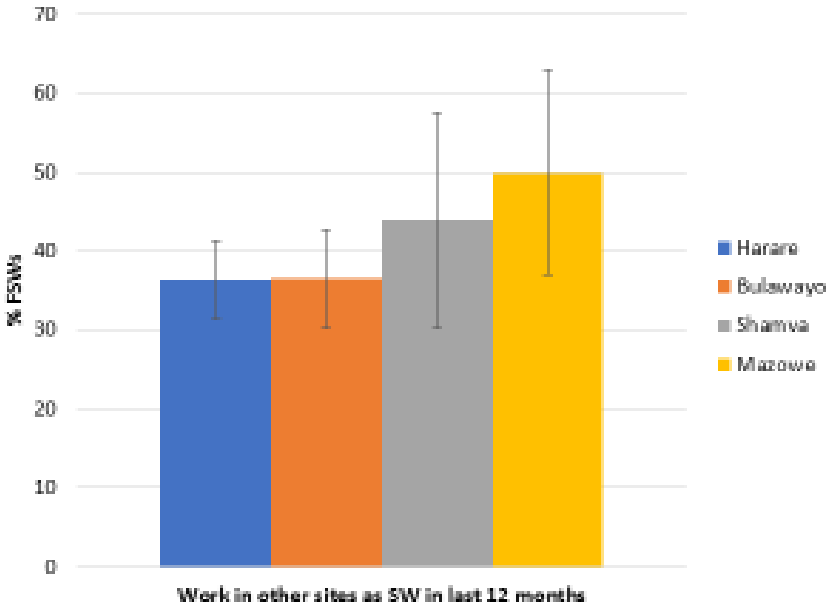
Figure 13. Food Insecurity of FSWs by Site



FSW = female sex worker.

Mobility to other sites to work as SWs in the past year was highest in Mazowe at 49.9% (95% CI, 36.9–63.0) and Shamva at 43.9% (95% CI, 30.3–57.4%). Mobility was lower in bigger cities, where approximately one-third of women reported travelling to work; in Harare, 36.6% (95% CI, 31.3–41.2) reported travelling to work, and in Bulawayo, 36.5% (95% CI, 30.2–42.7) reported the same. Figure 14 shows the percentage of FSWs who traveled for sex work by site.

Figure 14. Mobility to Work as SWs by Site

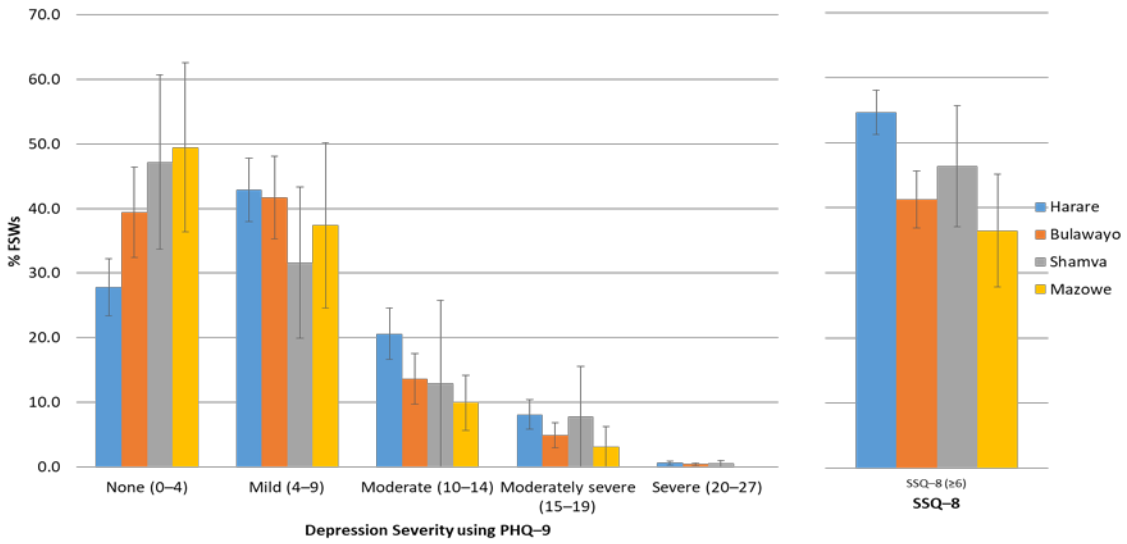


FSW = female sex worker; SW = sex worker.

We used two tools to assess mental health: the eight-item Shona Symptom Questionnaire (SSQ-8), a screening tool for common mental disorders, and the Patient Health Questionnaire-9 (PHQ-9), a diagnostic tool for depression. Both tools have been validated for use in Zimbabwe. We analyzed

SSQ-8 data with a cutoff ≥6 indicating risk of common mental disorders: Between 35% and 55% of FSWs were at risk. Perhaps not surprisingly, 15–30% of women scored above the threshold for moderate depression. Figure 15 shows the rate of depression among FSWs by site.

Figure 15. Prevalence of Common Mental Disorders and Depression among FSWs by Site



FSW = female sex worker; PHQ-9 = Patient Health Questionnaire-9; SSQ-8 = eight-item Shona Symptom Questionnaire.

Table 3 shows reported alcohol use among FSWs. In Harare, 26.5% of women reported that they had drunk no alcohol in the past 12 months, compared with 21.4% in Bulawayo, 28% in Shamva, and 22.8% in Mazowe. Among those who reported having drunk alcohol four or more times per week, 21.2% were in Harare, 23.8% were in Bulawayo, 24.5% were in Shamva, and 35.6% were in Mazowe. Of those who drank alcohol, almost a quarter reported that they had often drunk six or more drinks in one night in the past 12 months. Across all four sites, the most commonly used type of alcohol was bottled beer.

Table 3. Alcohol Use among FSWs by Site

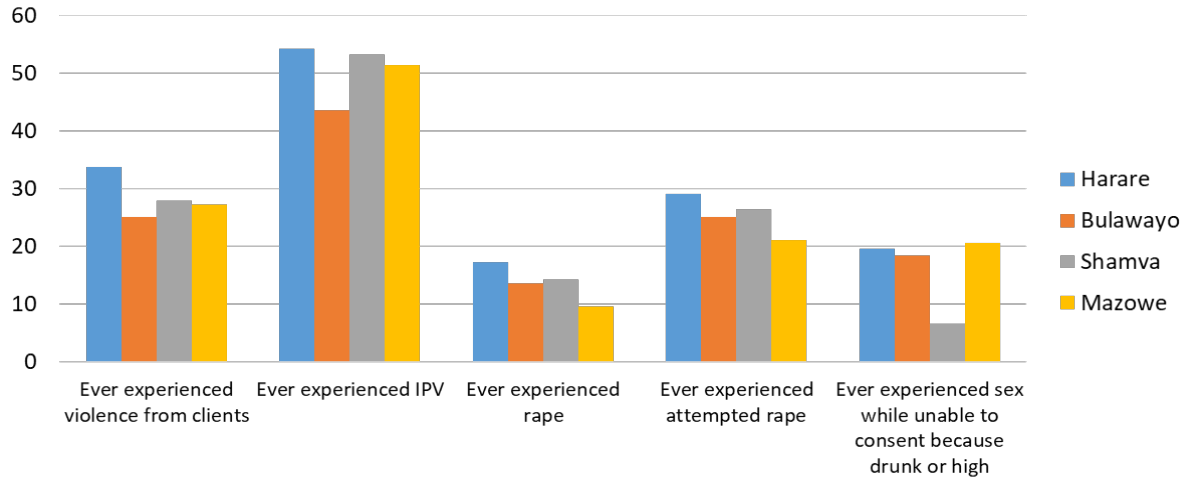
		Harare, *n* = 1,497				Bulawayo, *n* = 808				Shamva, *n* = 202				Mazowe, *n* = 200			
		No.	RDS-II Weighted, %	95% CI for RDS-II Weighted Proportion		No.	RDS-II Weighted, %	95% CI for RDS-II Weighted Proportion		No.	RDS-II Weighted, %	95% CI for RDS-II Weighted Proportion		No.	RDS-II Weighted, %	95% CI for RDS-II Weighted Proportion	
In the past 12 months, how often did you drink alcohol?	Never	406	26.5	22.2	30.8	172	21.4	16.5	26.3	57	28.0	16.3	39.8	53	22.8	12.4	33.3
	≤1 time per month	165	12.2	8.9	15.4	70	8.9	5.2	12.5	29	15.2	5.6	24.9	22	11.3	1.0	21.6
	2–4 times a month	185	13.5	9.8	17.2	87	12.1	7.3	17.0	14	6.3	2.5	10.1	16	4.9	2.9	6.9
	2–3 times a week	399	26.6	22.5	30.8	261	33.8	27.0	40.7	53	26.0	15.2	36.7	51	25.4	13.6	37.1
	≥4 times a week	342	21.2	17.0	25.4	218	23.8	18.7	28.8	49	24.5	10.0	38.9	58	35.6	23.0	48.1
Type of alcohol most frequently consumed (*n* = 1,091)	Home-brewed beer	17	1.8	0.0	3.9	8	1.7	0.3	3.1	5	3.8	0.0	11.8	5	7.1	0.0	16.5
	Bottled beer	637	59.7	54.1	65.4	390	57.1	49.6	64.6	83	52.9	36.8	69.0	100	59.1	43.5	74.8
	Wine	17	1.4	0.0	2.9	7	1.2	0.1	2.3	1	0.9	−0.3	2.1	1	3.3	0.0	13.2
	Cider	190	17.2	12.7	21.6	142	23.0	16.8	29.2	34	21.5	9.8	33.3	24	20.9	8.1	33.8
	Spirits	31	3.3	1.0	5.5	26	5.5	2.0	9.0	2	2.6	0.2	4.9	1	0.1	0.0	0.1
	Opaque beer	199	16.7	12.8	20.6	63	11.5	6.0	17.0	20	18.3	0.8	35.9	16	9.5	0.7	18.4
How often drink ≥6 drinks in one night in the past 12 months (*n* = 1,090)	Never	488	47.5	41.7	53.2	190	29.6	22.8	36.5	54	44.2	27.8	60.6	40	32.0	15.7	48.3
	≤1 per month	140	13.3	9.3	17.2	75	13.7	8.6	18.7	23	11.9	5.0	18.7	16	6.2	2.2	10.3
	2–4 times a month	125	11.6	8.2	15.0	70	12.3	6.6	17.9	14	8.9	4.3	13.4	18	8.4	2.6	14.2
	2–3 times a week	176	13.3	9.9	16.8	127	21.2	14.6	27.9	30	18.0	6.8	29.1	36	25.6	12.5	38.8
	≥4 times a week	161	14.3	9.4	19.3	174	23.2	17.7	28.6	24	17.1	5.0	29.2	37	27.7	15.5	40.0
How often failed to use condom with client because of own drinking in past 12 months?	Never	762	70.4	65.1	75.7	472	73.4	66.7	80.1	112	75.7	59.4	92.1	103	75.9	64.3	87.4
	Less than monthly	238	21.4	16.7	26.2	114	21.4	14.9	28.0	28	13.9	3.4	35.2	27	13.5	5.4	21.5
	Monthly	37	3.8	0.8	6.8	24	3.2	1.2	5.3	2	2.4	0.0	6.4	5	4.0	0.0	13.1
	Weekly	46	4.1	2.6	5.6	26	1.9	0.8	3.1	3	2.6	0.0	8.6	11	6.3	3.3	9.3
	Daily or almost daily	7	0.3	0.1	0.4	0	0.00	–	–	0	0.0	–	–	1	0.3	0.1	0.5
How often failed to use condom with client because of a client's drinking in past 12 months	Never	1305	88.4	85.8	91.1	712	89.2	86.1	92.2	181	87.6	74.9	100.0	177	89.8	82.8	96.8
	Less than monthly	148	9.1	6.8	11.5	69	8.7	5.8	11.6	20	12.2	0.0	24.9	18	6.5	0.3	12.7
	Monthly	16	0.9	0.0	1.9	12	1.4	0.5	2.3	0	0.0	–	–	3	2.2	0.0	5.5
	Weekly	22	1.4	0.7	2.0	15	0.7	0.3	1.1	1	0.2	0.1	0.2	2	1.5	1.1	2.0
	Daily or almost daily	5	0.2	0.1	0.3	0	0.0	5.2	12.5	0	0.0	–	–	0	0.0	–	–

CI = confidence interval; RDS-II = respondent-driven sampling.

Failure to use condoms because of the SW's drinking in the past month was very low, with most women reporting that they never failed to use condoms. In Harare, the proportion of women who reported that they never failed to use condoms because of their own drinking was 70.4%, compared with 73.4% in Bulawayo, 75.7% in Shamva, and 75.9% in Mazowe. The proportion of women who reported failing to use condoms because of a client's drinking was also very low.

The proportion of women who reported ever experiencing some form of GBV is shown in Figure 16. Intimate partner violence (IPV) was the most common type of violence women experienced, followed by violence from clients, attempted rape, followed by ever experiencing sex while unable to consent because of drunkenness. The lowest reported incidence of some form of GBV was ever having experienced rape.

Figure 16. FSWs Reporting Ever Experiencing Some Form of Violence from Clients or Intimate Partners



FSW = female sex worker; IPV = intimate partner violence.

Harare had the highest proportion of women reporting ever having experienced IPV, at 54.3% (95% CI, 49.3–59.2), followed by Shamva at 53.3% (95% CI, 39.9–66.7), Mazowe at 51.5% (95% CI, 38.3–64.7), and Bulawayo at 43.7% (95% CI, 37.1–50.2). IPV in the past 12 months was highest in Shamva, at 14.9% (95% CI, 1.3–28.6), followed by Mazowe at 14.2% (95% CI, 5.4–22.9), Harare at 12.6% (95% CI, 9.1–16.2), and Bulawayo at 9.2 (95% CI, 6.0–12.4).

Table 4 shows the proportion of women who reported harassment by police. The proportion of women who reported being stopped by police in the past year was 32.5% (95% CI, 27.9–37.0) in Harare, 26.2% (95% CI, 13.6–38.9) in Mazowe, 17.9% (95% CI, 13.2–22.7) in Bulawayo, and 13.9% (95% CI, 8.0–19.8) in Shamva. Verbal harassment by police in past year was lower than the proportion of women being stopped, as reported by 8.1% (95% CI, 3.5–12.6) of FSWs in Bulawayo,

8.0% (95% CI, 5.7–10.4) of FSWs in Harare, 2.2% (95% CI, 0.0–5.8) of FSWs in Shamva, and 0.6% (95% CI, 0.3–0.9) of FSWs in Mazowe.

Table 4. Women Who Reported Harassment by Police

	Harare, *n* = 1497				Bulawayo, *n* = 808				Shamva, *n* = 202				Mazowe, *n* = 200			
	No.	RDS-II Weighted, %	95% CI for RDS-II Weighted Proportion		No.	RDS-II Weighted, %	95% CI for RDS-II Weighted Proportion		No.	RDS-II Weighted, %	95% CI for RDS-II Weighted Proportion		No.	RDS-II Weighted, %	95% CI for RDS-II Weighted Proportion	
Stopped or harassed by police in past year	498	32.5	27.9	37.0	168	17.9	13.2	22.7	31	13.9	8.0	19.8	43	26.2	13.6	38.9
Stopped or harassed by police in the past month	148	10.2	7.2	13.3	41	4.3	2.5	6.2	2	0.8	0.5	1.0	5	4.0	−3.4	11.3
Verbally harassed by police in the past year	127	8.0	5.7	10.4	64	8.1	3.5	12.6	5	2.2	0.0	5.8	2	0.6	0.3	0.9
Verbally harassed by police in the past month	46	2.5	1.3	3.8	26	3.3	0.9	5.8	2	0.4	0.3	0.6	0	0.0	–	–

CI = confidence interval; RDS-II = respondent-driven sampling.

5.4 Outcome Results

5.4.1 HIV Prevalence and Treatment Cascade

HIV prevalence ranged from 54.4% to 59.2%, as shown in Table 5. These results are consistent with previous results observed in communities of SWs around Zimbabwe.

*Table 5. HIV Prevalence by Site**

Site	HIV Prevalence	95% CI
Harare	54.4	49.4–59.4
Bulawayo	52.2	45.5–59.0
Shamva	54.8	41.4–68.1
Mazowe	59.2	46.2–76.2

CI = confidence interval; HIV = human immunodeficiency virus.

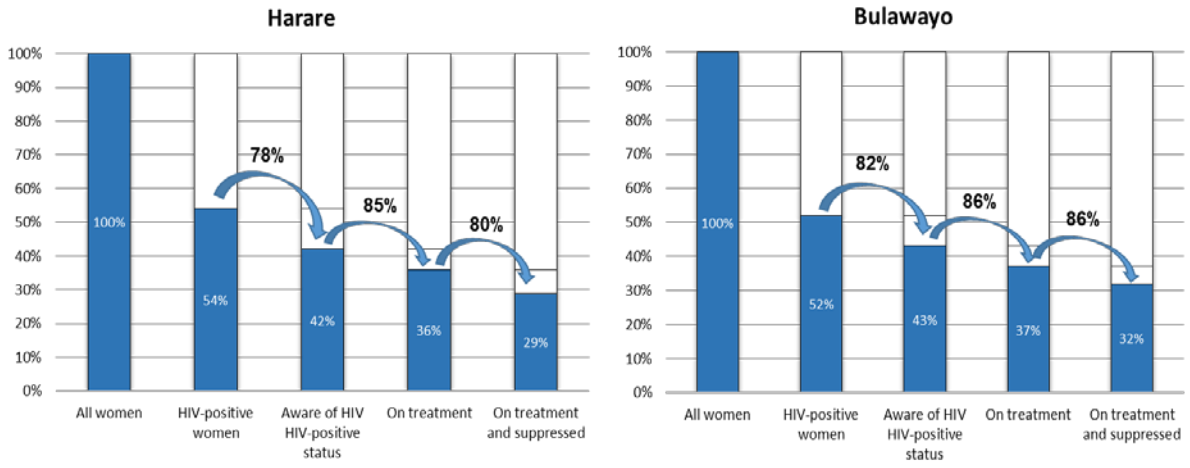
* Overall, 1,512 HIV-infected women, with results missing for 24 women.

The care cascade for women living with HIV was similar to that seen in the general female population in Zimbabwe. In Harare, the HIV prevalence was 54.4%. Of all women who tested HIV positive, 77.7% knew their HIV status; of these, 84.7% were on ART. Of those who knew their status and were on ART, 80.4% were virally suppressed. Because a subset of women did not know their status, the proportion of all HIV-positive women who were on ART was 65.7%; of these, 63.4% were virally suppressed. Among HIV-positive women, 9.3% (95% CI, 5.1–13.6) had a CD4 count of under 200 cells/ml; 34.9% (95% CI, 28.2–41.6) had a CD4 count 200–499 cells/ml; and 49.1% (95% CI, 42.4–55.9) had a CD4 count of ≥500 cells/ml. Among HIV-infected FSWs in Harare, 6.7% had a missing CD4 count.

In Bulawayo, HIV prevalence was 52.2%. Of all women who tested HIV positive, 82.3% knew their HIV status. Of these women, 85.9% were on ART. Of those who knew their status and were on ART,

85.6% were virally suppressed. Of all HIV-positive women, 70.7% where on treatment. Of these, 69.7% were virally suppressed. Figure 17 shows the care cascade for HIV-positive FSWs in Harare and Bulawayo. We found that 10.5% (95% CI, 4.1–16.8) of HIV positive women had a CD4 count of under 200 cells/ml, 40.6% (95% CI, 32.3–48.9) had a CD4 count 200–499 cells/ml, and 47.7% (95% CI, 39.4–55.9) had a CD4 count of ≥500 cells/ml. Among HIV-infected FSWs in Bulawayo, 1.3% had a missing CD4 count.

Figure 17. Care Cascade for HIV-Positive FSWs in Harare and Bulawayo



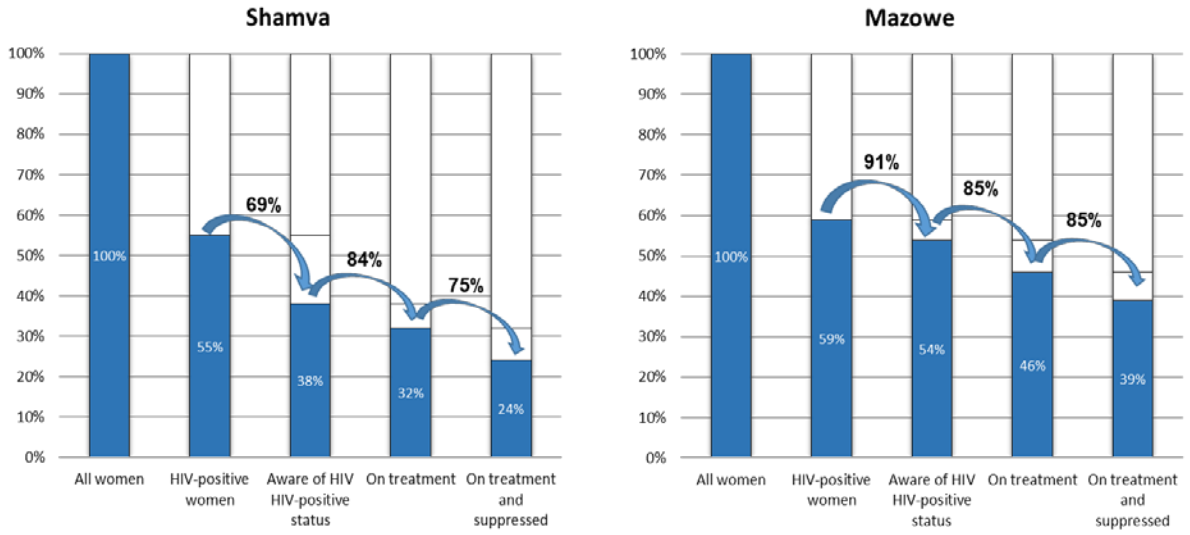
FSW = female sex worker; HIV = human immunodeficiency virus.

In Mazowe, HIV prevalence was 59.2%. Of all women who tested HIV positive, 91.1% knew their HIV status. Of these women, 84.8% were on ART. Of those who knew their status and were on ART, 85.3% were virally suppressed. Of all HIV-positive women, 77.2% where on treatment. Of these, 75.75% were virally suppressed. Of HIV-positive women, 5.1% (95% CI, 2.3–7.9) had a CD4 count of under 200 cells/ml; 34.3% (95% CI, 19.6–49.0) had a CD4 count 200–499 cells/ml; and 60.6% (95% CI, 45.2–75.9) had a CD4 count of ≥500 cells/ml. Among HIV-infected FSWs in Mazowe, 0% had a missing CD4 count.

In Shamva, HIV prevalence was 54.8%. Of all HIV-positive women, 68.5% knew their status. Of these, 84.6% were on ART. Of those who knew their status and were on ART, 70.4% were virally suppressed. Of all HIV-positive women, 58.0% where on treatment. Of these, 63.9% were virally suppressed. Shamva had the weakest care cascade compared with the other sites, with fewer women knowing their status. This lack of knowledge subsequently affected the care cascade. Shamva does not have a sex work–specific clinic like Bulawayo and Harare, where CeSHHAR has had a program for more than 10 years, and Mazowe, where CeSHHAR partners with PSI to offer services. Of HIV-positive women, 3.5% (95% CI, 0.0–7.0) had a CD4 count of under 200 cells/ml; 40.9% (95% CI, 23.0–58.7) had a CD4 count 200–499 cells/ml; and 48.0% (95% CI, 28.6–67.4) had a CD4 count of

≥500 cells/ml. In Mazowe, 7.6% of HIV infected FSWs had a missing CD4 count. Figure 18 shows the care cascade for HIV-positive FSWs in Shamva and Mazowe.

Figure 18. Care Cascade for HIV-Positive FSWs in Shamva and Mazowe



FSW = female sex worker; HIV = human immunodeficiency virus.

Table 6 shows the overall proportion of HIV-infected women who had a suppressed HIV viral load (<1,000 copies/mL).

Table 6. Overall Proportion of HIV-Infected FSWs Who Are Virologically Suppressed by Site*

Site	HIV Prevalence	95% CI
Harare	63.4	56.2–70.6
Bulawayo	69.7	61.3–78.2
Shamva	63.9	45.5–82.3
Mazowe	75.7	63.4–88.0

CI = confidence interval; FSW = female sex worker; HIV = human immunodeficiency virus.

* Compared with the Zimbabwe Population-Based HIV Impact Assessment for all adult women 15–64 years of age of 64.5%.

5.4.2 STI Prevalence

For all women, we ran syphilis serology. We randomly selected one in three participants to undergo genital examination and be screened for STIs. In practice, fewer than one in three women underwent STI testing; we will undertake a comparison of characteristics among responders and nonresponders. The main reason for FSWs declining STI testing was menstruation. Many nonresponders indicated that they would return on another day for STI testing, but then failed to do so. Weighted STI prevalences are shown in Table 7. Prevalence of gonorrhea ranged from 6.8% to 21.5%, for chlamydia from 6.4% to 10.1%, and for *T. vaginalis* from 26.6% to 39.4%. High-risk HPV was common, with 37.3–49.0 having any high-risk HPV. Between 13% and 19.9% of women had positive syphilis serology (TPHA and RPR).

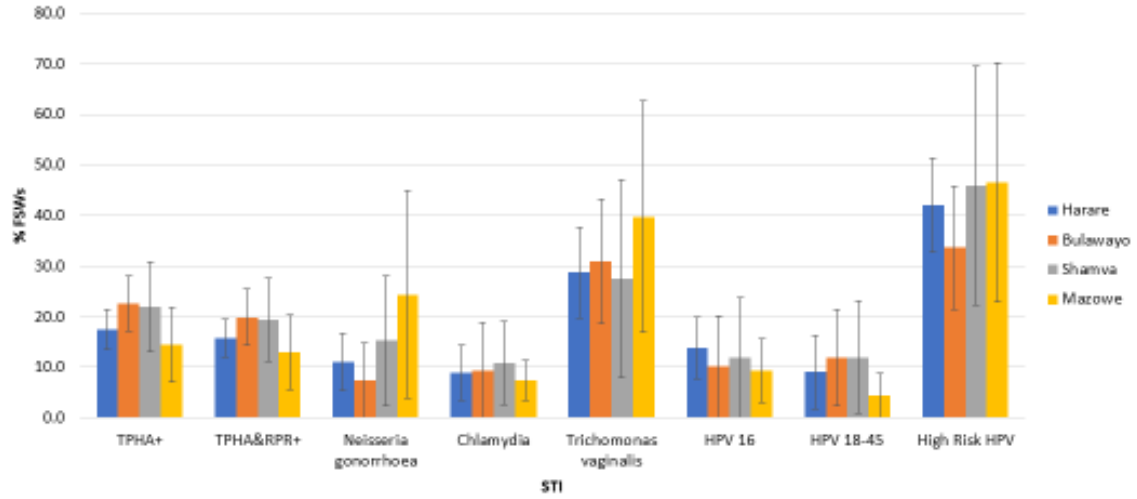
Table 7. Weighted Prevalence of STIs by Site

	Harare				Bulawayo				Shamva				Mazowe			
STIs: lab testing	**n**	**Weighted %**	**95% CI ***		**n**	**Weighted %**	**95% CI ***		**n**	**Weighted %**	**95% CI ***		**n**	**Weighted %**	**95% CI ***	
Syphilis: TPHA positive	252/1497	17.5	13.5	21.6	184/808	22.6	17.1	28.2	46/202	22.0	13.1	30.9	39/200	14.5	7.1	21.9
Syphilis: TPHA and RPR positive	227/1497	15.8	12.0	19.6	159/808	19.9	14.4	25.5	39/202	19.4	11.2	27.6	36/200	13.0	5.7	20.4
Neisseria gonorrhoea	47/406	10.5	5.1	15.9	16/210	6.8	0.0	14.4	14/58	14.3	2.6	26.0	12/62	21.5	3.5	39.6
Chlamydia	38/406	8.4	3.3	13.6	17/210	8.6	0.0	20.9	6/58	10.1	2.6	17.5	4/62	6.4	3.1	9.7
Trichomonas vaginalis	114/406	27.6	19.0	36.2	65/210	30.2	18.2	42.1	19/58	26.6	7.9	45.3	28/62	39.4	17.1	61.8
HPV Type 16	53/406	13.0	7.4	18.6	24/210	9.2	0.0	18.9	9/58	9.2	0.0	18.8	5/62	8.9	3.1	14.6
HPV Type 18-45	41/406	9.3	2.6	15.9	22/210	10.9	2.0	19.8	10/58	9.3	1.1	17.5	4/62	4.5	0.0	10.0
High Risk HPV	157/406	39.5	30.5	48.5	68/210	31.0	19.6	42.4	23/58	35.7	14.2	57.2	29/62	45.2	22.5	68.0
Any of the above high risk HPV	190/406	47.5	38.0	57.0	85/210	37.3	24.8	49.8	30/58	42.2	18.8	65.6	31/62	49.0	26.3	71.6

CI = confidence interval; HPV = human papilloma virus; RPR = rapid plasma reagin; STI = sexually transmitted infection; TPHA = *Treponema pallidum* hemagglutination assay.

Figure 19 shows STI prevalence among FSWs by site.

Figure 19. STI Prevalence among FSWs by Site



FSW = female sex worker; HPV = human papilloma virus; RPR = rapid plasma reagin; STI = sexually transmitted infection; TPHA = *Treponema pallidum* hemagglutination assay.

5.5 Population Size Estimates

5.5.1 Summary of Population Size Estimates Diagnostics

Harare:

- Convergence of Sisters clinic attendance was reasonable.
- The proportion of women who received a wristband might have continued to decline with more recruitment, but it appears close to converging. If we overestimated the proportion of FSWs receiving a wristband, we would have underestimated our periodic screening evaluation.

Bulawayo:

- Convergence of the proportion of FSWs attending the clinic was good, as was the proportion receiving a wristband in the first round.
- We might have slightly overestimated the proportion of FSWs receiving a wristband in the second round, but convergence was not a major problem.

Shamva:

- Neither the estimate for receiving a wristband in the first round nor the estimate for receiving a wristband in the second round appears to have converged. Convergence was worse for the first-round wristband estimate; we might have overestimated the proportions for each of these variables and consequently underestimated the periodic screening evaluation in both cases, but especially for the first round.

- The same number of (different) women reported receiving the first- and second-round wristbands, but the RDS-weighted proportions differ. In the second round, the RDS weighting significantly lowered the proportion of FSWs receiving the wristband because several women who did not receive the wristband had a small client network size. Thus, their responses were weighted upward because we expected that we would sample these women later.

Mazowe:

- Convergence for the first-round wristband was reasonable.
- The estimate for the second-round wristband could have stopped declining had we continued to recruit, which means that we could have underestimated the proportion receiving a wristband.

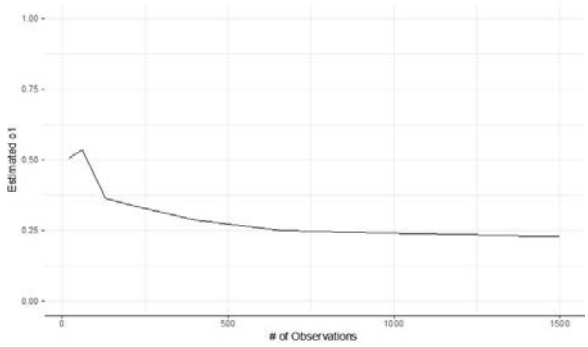
5.5.2 Summary of Population Size Estimates by Method

In all but two cases—the second wristband round in Mazowe and the first wristband round in Shamva—women who reported receiving a wristband or attending the Sisters clinic had a higher mean reported network size than women who did not. This reporting is plausible and highlights the importance of weighting for the RDS design. Recruitment homophily was fairly low for each unique object and service multiplier used: There was a tendency for women to recruit others like themselves, but the tendency was not high (ranging from 1.01 to 1.16, where 1 is equal to no preferential recruitment by these variables and 2 is equal to having twice the probability of recruiting someone of the same status as would be expected by chance given the distribution of characteristics).

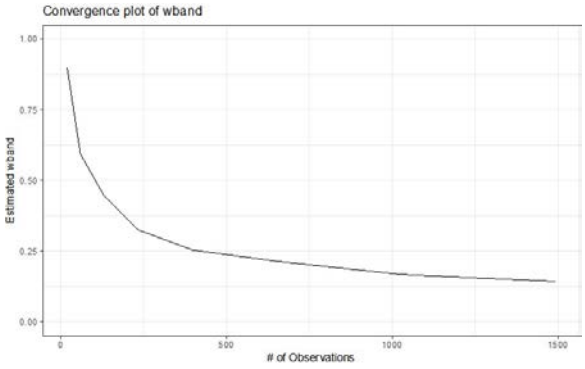
In Harare, the convergence of the Sisters attendance estimate was better than for the wristband receipt estimates, but this was not the case in Bulawayo, where it was similar. In Bulawayo, Shamva, and Mazowe, no consistent pattern was found in whether first- or second-round wristband distribution was better (nor in whether the first- or second-round estimate was higher or lower), making it difficult to comment systematically on which PSEs were better across sites. We are aware that the distribution of wristbands occurred much earlier in Harare (8 weeks prior to the survey), which casts doubt on the resulting PSEs, along with the relatively poor convergence. This was not necessarily the case for the other sites. Figures 20 through 23 show the convergence of cumulative weighted prevalence for FSWs attending a Sisters clinic in the previous 6 months and receiving a wristband by site.

Figure 20. Convergence of Cumulative Weighted Prevalence of FSWs in Harare (a) Attending the Sisters Clinic in the Previous 6 Months over Sample Waves and (b) Receiving a Wristband over Sample Waves

(a)



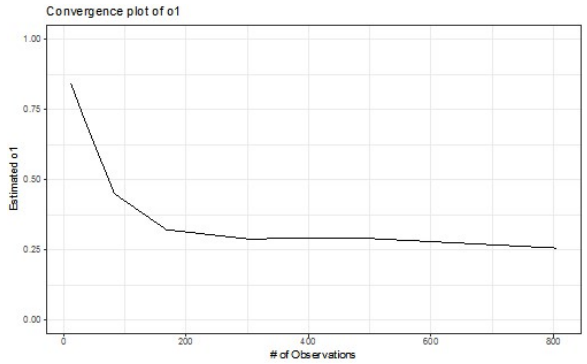
(b)



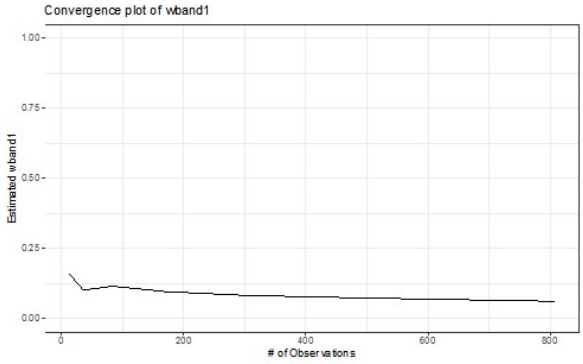
FSW = female sex worker.

Figure 21. Convergence of Cumulative Weighted Prevalence of FSWs in Bulawayo (a) Attending the Sisters Clinic in the Previous 6 Months over Sample Waves, (b) Receiving a First-Round Wristband over Sample Waves, and (c) Receiving a Second-Round Wristband over Sample Waves

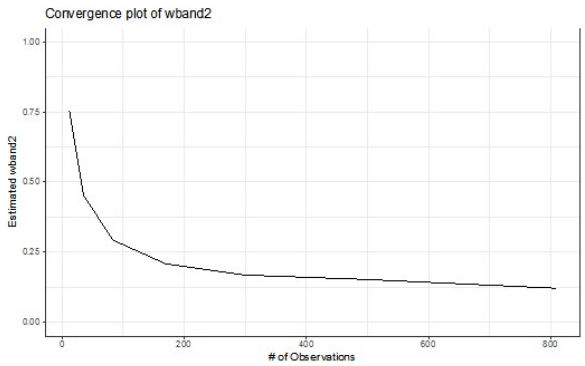
(a)



(b)

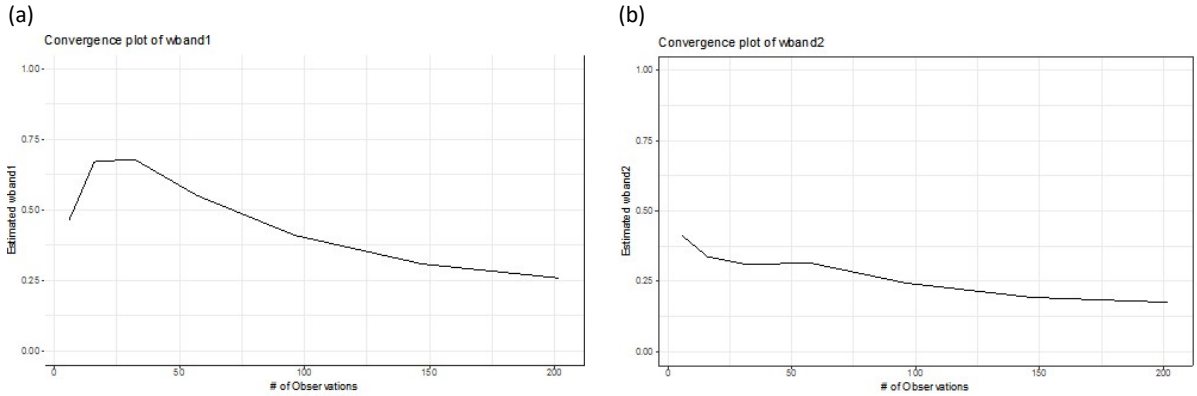


(c)



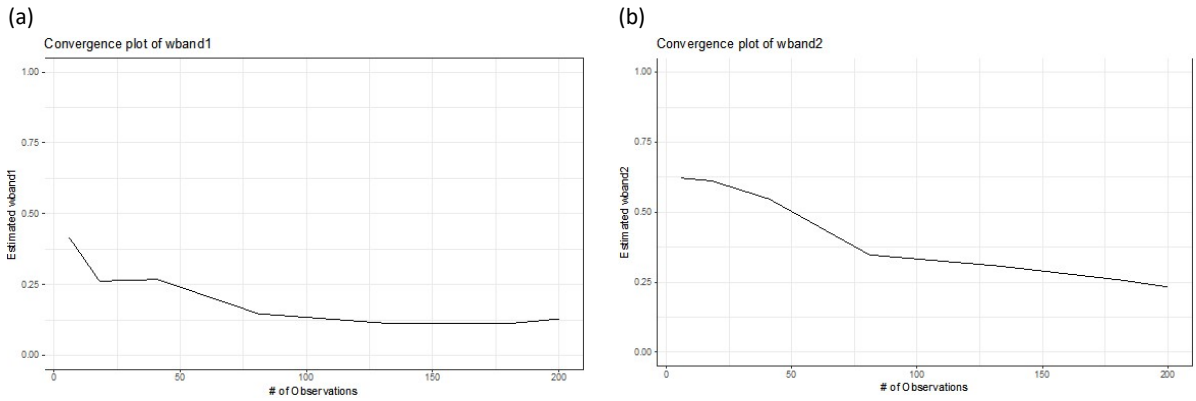
FSW = female sex worker.

Figure 22. Convergence of Cumulative Weighted Prevalence of FSWs in Shamva (a) Receiving a First-Round Wristband over Sample Waves and (b) Receiving a Second-Round Wristband over Sample Waves



FSW = female sex worker.

Figure 23. Convergence of Cumulative Weighted Prevalence of FSWs in Mazowe (a) Receiving a First-Round Wristband over Sample Waves and (b) Receiving a Second-Round Wristband over Sample Waves



FSW = female sex worker.

5.5.3 Size Estimates

Table 8 shows population size estimates for the four sites.

For Harare, the population size estimate ranges between 1.5% and 2.5% of the adult female population 15–49 years of age, with the actual number of SWs ranging from 7,629 to 12,863. For Bulawayo, the population size estimate ranges between 3.3% and 5.0% of the adult female population 15–49 years of age, with the actual number of SWs ranging between 5,687 and 8,264.

In Shamva, we counted 132 women at the census and estimated 391–684 women, using the UOMM. The population estimates range between 9.3% and 16.3%. In Mazowe, we counted 180 women at the census and estimated 613–1,553 women, using the UOMM. The population estimates range between 3.6% and 9.1%.

Table 8. Recruitment Homophily and Average Network Size by the Variables Used in Multiplier Population Size Estimates for Each Site

	M: No. of Women Attending Sisters in Previous 12 Months or Receiving Wristband	Unweighted Proportion Reporting Attendance or Receipt of Object in RDS Survey	RDS-II Weighted Percentage Attending Clinic or Receiving Wristband	95% CI for RDS Weighted Percentage		Population Size Estimate	95% CI Around Population Size Estimate		% of Female Population 15–49 Years of Age	95% CI	
	Harare										
SMM estimate	3,088	375/1,497, 25.1%	22.9	19.1	26.8	**13,473**	11,165	15,781	2.7	2.2	3.1
SMM, adj. 4.53% duplicates	2,948	375/1,497, 25.1%	22.9	19.1	26.8	**12,863**	10,6657	15,068	2.5	2.1	3.0
UOMM estimate	1,091	243/1,493, 16.3%	14.3	11.9	16.8	**7,629**	6,246	9,013	1.5	1.2	1.8
	Bulawayo										
SMM estimate	1,532	239/805, 29.7%	25.6	20.4	30.8	**5,987**	4,744	7,229	3.5	2.8	4.2
SMM, adj 5.00% duplicates	1,456	239/805, 29.7%	25.6	20.4	30.8	**5,687**	4,505	6,870	3.3	2.6	4.0
UOMM estimate: first round	524	70/808, 8.7%	6.5	4.0	8.3	**8,504**	5,414	11,593	**5.0**	3.2	6.8
UOMM estimate: second round	1,000	103/808, 12.7%	12.1	7.9	16.4	**8,264**	5,301	11,227	**4.8**	3.1	6.6
	Shamva										
UOMM estimate: first round	101	52/202, 25.7%	25.9	16.8	34.9	**391**	234	547	**9.3**	5.6	13.0
UOMM estimate: second round	120	52/202, 25.7%	17.6	9.5	25.6	**684**	349	1,018	**16.3**	8.3	24.3
	Mazowe										
UOMM estimate: first round	200	30/200, 15.0%	12.9	5.6	20.2	**1552**	646	2,457	**9.1**	3.8	14.4
UOMM estimate: second round	143	46/200, 23.0%	23.3	13.7	33.0	**613**	339	887	**3.6**	2.0	5.2

CI = confidence interval; RDS = respondent-driven sampling; SMM = service multiplier method; UOMM = uncertainty of measurement method.

Taking the median value of the two estimates at each site gives a population estimate of 10,246 in Harare (lower and upper plausibility bounds 7,629–12,863) and 6,976 in Bulawayo (lower and upper plausibility bounds 5,687–8,264). However, following consultation with principal investigators from the Ministry of Health and Child Care and National AIDS Council (NAC), the ratio of FSWs in Harare to Bulawayo was believed to be inaccurate. Given the fact that UOMM was circulated in Harare 8 weeks prior to survey, convergence was somewhat poor for receipt of wristband; it was agreed use just the single estimate for Harare of 12,863. In Shamva district, the estimate based on median is 408 (lower and upper plausibility bounds 132–684) and in Mazowe district, 397 (lower and upper plausibility bounds 180–613).

6.0 Discussion

This study is the first attempt to estimate the size of the FSW population in Harare, Bulawayo, and two districts in Mashonaland Central Province (Shamva and Mazowe). For each site, two methods were used to estimate population size (in Harare and Bulawayo, SMM and UOMM were used, and in Shamva and Mazowe census and UOMM were used). The range in estimates is wide. In Harare and Bulawayo, estimates suggest that 2–4% of the adult female population 15–49 years of age is selling sex. The PSE in Shamva and Mazowe are more wide ranging. As found in previous studies, the prevalence of HIV is high (52–59%); reassuringly, however, engagement in the care cascade is similar to that of adult women more generally, although it is still far from the UNAIDS 90–90–90 target. Of importance, this study also provides the first estimates of STI prevalence among Zimbabwean FSWs in well over a decade. Rates of bacterial STIs are high, and indicate ongoing unprotected sex as well as inadequate management of STIs.

While there are valid criticisms of individual population size estimation methods (Abdul-Quader, Baughman, & Hladik, 2014), there is no gold standard, and differing methods often give different results in the same population. We have described and reported on our methods for investigating possible sources of bias likely affecting our size estimates. We have conducted recommended diagnostics on our RDS estimates and adjusted our program records for possible duplication of unique identifiers. In some cases, we determined that the RDS estimates used in size estimation might not have been representative, and we offer interpretations on how this may have affected our size estimates. In Shamva and Mazowe, we found much lower estimates using the census method than using UOMM, possibly because there were FSWs who were missed in this venue-based method. In line with previous studies, we did not find consistent tendencies for either higher or lower estimates using the SMM or UOMM in Harare and Bulawayo.

Earlier in 2017, Wesson and colleagues published the results of a systematic review that aimed to document the methods used for size estimation of hidden or hard-to-reach populations, and to determine the extent to which the different methods gave the same results (Wesson, Reingold, & McFarland, 2017). They identified 341 publications, of which 25 reported on studies that used multiple methods and therefore allowed direct comparison among methods. SMM was the most commonly used method. Of note, the review was unable to identify a “best” method. The authors found that all methods could result in estimates that were biased up or down and observed little agreement among methods. They noted trends in the relative performance of individual methods: (1) size estimation based on applying findings from the literature and extrapolating to other settings or those using the Delphi method tend to provide estimates in the middle of the range; (2) estimates

using “wisdom of the crowd” or mapping tend to be low; and (3) multiplier methods and capture–recapture estimates can be high or low.

Despite these difficulties, a consensus about adequate approaches for obtaining size estimates is emerging and is outlined in UNAIDS/WHO guidelines (UNAIDS/WHO Working Group on Global HIV/AIDS and STI Surveillance, 2011). In a recent review of quality and availability of size estimates for key populations from low- and middle-income countries (Sabin et al., 2016), to be considered nationally or locally adequate, estimates should be derived using at least two of the following methods: (1) multiplier; (2) capture–recapture; (3) mapping/enumeration; (4) network scale-up or population survey; or (5) RDS-SS successive sampling (SS). In this study, at least two methods of acceptable quality were used at each site, and the possibility of exploring estimates using network scale up or RDS-SS remains. Previous studies have suggested using the median of estimates derived using different size estimation methods, which are then checked with community representatives and stakeholders for plausibility (Okal et al., 2013). The upper and lower estimates can be used as plausibility bounds. Using this approach—taking the median value of the two estimates at each site—yields a population estimate of 10,246 in Harare (lower and upper plausibility bounds 7,629–12,869) and 6,976 in Bulawayo (lower and upper plausibility bounds 5,687-8,264). In Shamva district, the estimate based on median is 408 (lower and upper plausibility bounds 132–684) and in Mazowe district 397 (lower and upper plausibility bounds 180–613). Note, however, that these estimates have not yet been presented to community groups and stakeholders more broadly to get feedback on their plausibility. Of note, principal investigators from the Ministry of Health and Child Care and National AIDS Council felt that the median measure for Harare would be too low, given the size estimate for Bulawayo and the fact that UOMM was distributed 8 weeks prior to the survey. In view of this, it has been agreed to present the Harare estimate based on the SMM.

The estimates of FSW population size are within the range found elsewhere in Africa. In a systematic review of size estimates among FSWs, the prevalence of sex work in African adult females ranged between 0.4% and 4.3% in urban areas (Vandepitte et al., 2006). More than 70 size estimation studies among FSWs have been conducted over the last 10 years, with approximately 50 resulting in locally or nationally “adequate size” estimates. Of note, these studies found that where population size estimates were conducted at several time points, there is no compelling evidence of dramatic changes in key population size. That said, sex work populations are dynamic, with women moving both in and out of sex work and between geographic locations to work.

In terms of sociodemographic characteristics of SWs and their HIV prevalence and engagement with services, the findings concur with other representative survey data collected in Zimbabwe (Busza et

al., 2017; F. Cowan et al., 2016). HIV prevalence was high and SWs had similar levels of engagement in services with women in the general population (ICAP, 2016). Services will need to be intensified if UNAIDS' ambitious targets for 90–90–90 are to be met (UNAIDS, 2014). Of note, these are the first data on STI prevalence in SW collected in Zimbabwe since 2001. Rates of syphilis, gonorrhea, chlamydia, and trichomonas were very high, suggesting that unprotected sex is more common than reported. It is well known that syndromic management of STIs is less effective in women than men. Detailed additional analyses to explore the extent to which STIs were symptomatic will be conducted.

The strengths of this study are that a rigorous preplanned approach was used, with appropriately justified sample sizes (Fearon, Chabata, Thompson, Cowan, & Hargreaves, 2017) Two of the recommended size estimation methods were used in each site, and results triangulated to give upper and lower plausibility bounds of those estimates. RDS diagnostics did not reveal major biases in survey recruitment. The surveys in Harare and Bulawayo were large and allowed for relatively precise estimation of sociodemographic characteristics and engagement with the care cascade. There is scope for continued analysis and refinement of the estimates through conduct of additional analysis, as already outlined.

In terms of limitations, conducting the UOMM was somewhat compromised in Harare, where the start of the survey was delayed as a result of a delay in shipment of laboratory test kits. The unique object was distributed 8 weeks prior to the start of the survey in Harare. The proportion of survey participants reporting receipt of a wristband was close to converging. It is possible, however, that we overestimated the proportion reporting receipt of the wristband. This would have led to the population size in Harare being underestimated by this method.

6.1 Recommendations for the Communication of Size Estimates

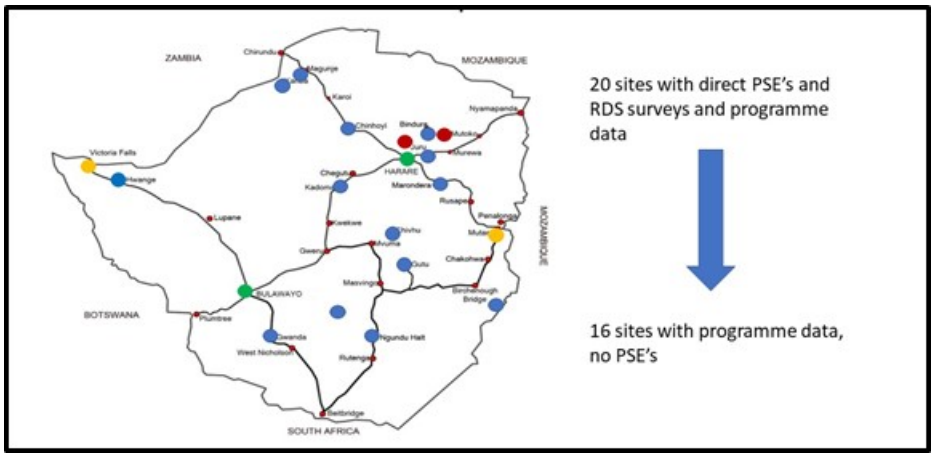
There is uncertainty around the precision of these estimates, and a consensus needs to be reached about how best to communicate this uncertainty. It is simpler for policy makers and funders to deal with point estimates, which have wide plausibility bounds. However, there is concern about presenting estimates with a lower and upper plausibility, as it allows stakeholders to use the estimate that best suits their purpose (e.g., to either under- or overestimate the number of FSWs). In addition, there are important and legitimate concerns about the ethics of releasing data into the public domain. There are numerous examples of such data being used to infringe on human rights (e.g., as a rationale for police crackdown/harassment). IRB approval was based on the premise that all data would be anonymized, so mapping reports with identifying data will not be shared.

6.2 Planned Approach to Developing National Size Estimate

Zimbabwe has representative survey data and direct size estimates among FSWs from 16 sites across the country in 2016, in addition to the size estimates presented here. This represents considerably more data than any other site included in Sabin's recent review. How do we convert this wealth of data into a nationally adequate size estimate to guide policy and planning in Zimbabwe?

To convert locally adequate estimates from specific sites to a nationally adequate estimate requires a clear and agreed approach to extrapolation (Sabin et al., 2016). In June 2017, CeSHHAR Zimbabwe, in collaboration with MeSH, held a workshop with representatives from CDC Zimbabwe, USAID Zimbabwe, Ministry of Health and Child Care, National AIDS Council, and RTI. The purpose of the workshop was to review size estimation methods and to agree on an approach to amalgamate data from this study, with Sisters program data and direct size estimates collected as part of the SAPPH-IRe trial, to come up with a national size estimate. In summary, RDS survey data and size estimates are available from 20 sites around Zimbabwe. The Sisters program operates in all 20 of these sites, plus 16 additional sites (Figure 24). It was agreed that we would explore extrapolating size estimates from sites with direct estimates plus program data to sites that only have program data. There was broad consensus among meeting attendees that between 75% and 85% of all SWs nationally had the potential to access the Sisters program through one of its 36 sites. A list of additional hotspots not covered by the Sisters program was made for each province. Hotspots that were considered broadly similar to each other were then matched. Matching criteria included (1) presence of Sisters program, (2) number of Sisters program attendees in 2017 Q1, (3) type of site, population at site, urban/rural and province, and (4) expert knowledge from within the program. This matching exercise will be used to extrapolate estimates with known population size to those without. The national estimate from this approach will be triangulated with data from nationally representative surveys such as Zimbabwe's Population HIV Impact Assessment and the Demographic Health Surveyto see how numbers compare. Of note, it is an iterative process and the estimates will need to continue to be refined going forward.

Figure 24. FSWs in Zimbabwe: Extrapolation to 36 Sites



6.3 Recommendations

- Continue to refine size estimates as new data emerge.
- Undertake additional analyses when rates of recent infection are established (funded by BMGF through MeSH consortium) and assess the feasibility of using network and RDS-SS techniques.
- Strengthen SW programming to improve engagement of SWs with both HIV and sexual and resproductive health services. Explore additional approaches above and beyond syndromic management to treat STIs.
- Conduct additional research/programming to address factors that increase the risk of HIV among Zimbabwean SWs, such as poor mental health and substance use.

7.0 Appendices

We include the CDC-approved Protocol, the CDC approved RDS SOP, the CDC approved RDS Questionnaire, and the Mapping Reports (for internal use only and not for circulation) as inclusions to this report.

8.0 References

Abdul-Quader, A. S., Baughman, A. L., & Hladik, W. (2014). Estimating the size of key populations: current status and future possibilities. *Curr Opin HIV AIDS, 9*(2), 107-114. doi:10.1097/coh.0000000000000041

Arnott, J., & Crago, A.-L. (2009). *Rights not rescue: A report on female, male, trans sex workers' human rIghts in Botswana, Namibia, and South Africa*. Retrieved from New York:

Busza, J., Mtetwa, S., Fearon, E., Hofisi, D., Mundawara, T., Yekeye, R., . . . Cowan, F. M. (2017). Good News for Sex Workers in Zimbabwe: How a court order improved safety in the absence of decriminalisation. *Journal of the International AIDS Society, in press*.

Chabata, S. (2015). *Estimating the size of the female sex worker population in urban and rural communities in Zimbabwe* (MSc Medical Statistics), London School of Hygiene and Tropical Medicine,

Cowan, F., Davey, C., Fearon, E., Mushati, P., Dirawo, J., Cambiano, V., . . . Hargreaves, J. (2016). The HIV care cascade among female sex workers in Zimbabwe: results of a population-based survey from the Sisters Antiretroviral therapy Programme for Prevention of HIV, an Integrated Response (SAPPH-IRe) Trial. *Journal of Acquired Immune Deficiency Syndrome, in press*.

Cowan, F. M., Davey, C. B., Fearon, E., Mushati, P., Dirawo, J., Cambiano, V., . . . Hargreaves, J. R. (2017). The HIV Care Cascade Among Female Sex Workers in Zimbabwe: Results of a Population-Based Survey From the Sisters Antiretroviral Therapy Programme for Prevention of HIV, an Integrated Response (SAPPH-IRe) Trial. *J Acquir Immune Defic Syndr, 74*(4), 375-382. doi:10.1097/qai.0000000000001255

Cowan, F. M., Mtetwa, S., Davey, C., Fearon, E., Dirawo, J., Wong-Gruenwald, R., . . . Hargreaves, J. R. (2013). Engagement with HIV prevention treatment and care among female sex workers in Zimbabwe: a respondent driven sampling survey. *PLoS One, 8*(10), e77080. doi:10.1371/journal.pone.0077080

Drain, P. K., & Garrett, N. (2015). *Assessment of the Xpert® HIV-1 Viral Load assay in a South African HIV Clinic.* Paper presented at the 8th IAS Conference on HIV Pathogenesis, Treatment and Prevention Vancouver.

Egger, M., Pauw, J., Lopatatzidis, A., Medrano, D., Paccaud, F., & Davey Smith, G. (2000). Promotion of condom use in a high-risk setting in Nicaragua: a randomised controlled trial. *Lancet, 355*, 2101-2105.

Fearon, E., Chabata, S. T., Thompson, J. A., Cowan, F. M., & Hargreaves, J. R. (2017). Sample Size Calculations for Population Size Estimation Studies Using Multiplier Methods With Respondent-Driven Sampling Surveys. *JMIR Public Health Surveill, 3*(3), e59. doi:10.2196/publichealth.7909

Gage, A. J., & Ali, D. (2005). Factors associated with self-reported HIV testing among men in Uganda. *AIDS Care, 17*(2), 153-165.

Gile, K. J., & Handcock, M. S. (2010). Respondent-driven sampling: An assessment of current methodology. *Sociological Methodology, 40*(1), 285-327.

Gile, K. J., Johnston, L. G., & Salganik, M. J. (2015). Diagnostics for respondent-driven sampling. *Journal of the Royal Statistical Society. Series A (Statistics in Society), 178*(1), 241-269. doi:10.1111/rssa.12059

Handcock, M. S., Fellows, I. E., & Gile, K. J. (2016). RDS: respondent-driven sampling, Version 0.7-8. Retrieved from Project home page at http://hpmrg.org/, http://cran.r-project.org/package=RDS

Hargreaves, J. R., Fearon, E., Davey, C., Phillips, A., Cambiano, V., & Cowan, F. M. (2016). Statistical design and analysis plan for an impact evaluation of an HIV treatment and prevention intervention for female sex workers in Zimbabwe: a study protocol for a cluster randomised controlled trial. *Trials, 17*, 6. doi:10.1186/s13063-015-1095-1

Hargreaves, J. R., Mtetwa, S., Davey, C., Dirawo, J., Chidiya, S., Benedikt, C., . . . Cowan, F. M. (2015). Cohort analysis of programme data to estimate HIV incidence and uptake of HIV-related services among female sex workers in Zimbabwe, 2009-14. *J Acquir Immune Defic Syndr*. doi:10.1097/qai.0000000000000920

ICAP. (2016). *Zimbabwe Population-Based HIV Impact Assessment: ZIMPHIA 2015-2016, Summary sheet preliminary findings*. Retrieved from

Ilse, P., & Loren, B. (2003). You are just whores: You can't be raped: Barriers to safer sex practices among women street sex workers in Cape Town. *Culture, Health & Sexuality, 5*(6), 465-481.

Johnston, L. G., Prybylski, D., Raymond, H. F., Mirzazadeh, A., Manopaiboon, C., & McFarland, W. (2013). Incorporating the service multiplier method in respondent-driven sampling surveys to estimate the size of hidden and hard-to-reach populations: case studies from around the world. *Sex Transm Dis, 40*(4), 304-310. doi:10.1097/OLQ.0b013e31827fd650

Kayembe, P. K., Mapatano, M. A., Busangu, A. F., Nyandwe, J. K., Musema, G. M., Kibungu, J. P., . . . Mayala, G. M. (2008). Determinants of consistent condom use among female commercial sex workers in the Democratic Republic of Congo: implications for interventions. *Sexually Transmitted Infections, 84*(3), 202-206. doi:10.1136/sti.2007.028324

Kriitmaa, K., Testa, A., Osman, M., Bozicevic, I., Riedner, G., Malungu, J., . . . Abdalla, I. (2010). HIV prevalence and characteristics of sex work among female sex workers in Hargeisa, Somaliland, Somalia. *AIDS, 24*, S61-S67 10.1097/1001.aids.0000386735.0000387177.0000386732a.

Kuhn, L. (2015). *Point-of-Care (POC) HIV Diagnosis for Newborn Infants*. Paper presented at the 8th IAS Conference on HIV Pathogenesis, Treatment and Prevention Vancouver.

Maman, S., Mbwambo, J., Hogan, N. M., Kilonzo, G. P., & Sweat, M. (2001). Women's barriers to HIV-1 testing and disclosure: challenges for HIV-1 voluntary counselling and testing. *AIDS Care, 13*(5), 595-603.

Mor, O., Gozlan, Y., Wax, M., Mileguir, F., Rakovsky, A., Noy, B., . . . Levy, I. (2015). Evaluation of HIV-1 RealTime, Xpert HIV-1 and Aptima HIV-1 Quant Dx assays in 1comparison to the NucliSens EasyQ v2.0 HIV-1 assay for quantification of HIV-1 2 viral load. *J. Clin. Microbiol.* doi:doi:10.1128/JCM.01806-15

Mshana, G. H., Wamoyi, J., Busza, J., Zaba, B., Changalucha, J., Kaluvya, S., & Urassa, M. (2006). Barriers to accessing antiretroviral therapy in Kisesa, Tanzania: a qualitative study of early rural referrals to the national program. *AIDS Patient Care STDS, 20*(9), 649-657.

Mungati, M., Mugurungi, O., Machiha, A., Tshimanga, M., Kilmarx, P., Nyakura, J., . . . Rietmeijer, C. (2015). *Performance of GeneXpert® CT/NG in the diagnosis of Neisseria gonorrhoeae and Chlamydia trachomatis among men and women with genital discharge syndrome in Zimbabwe.* Paper presented at the World STI & HIV Congress 2015, Brisbane, Australia.

Munoz, J., Adedimeji, A. A., & Alawode, O. (2010). 'They bring AIDS to us and say we give it to them': Socio-structural context of female sex workers' vulnerabiity to HIV infection in Ibadan Nigeria. *Journal of Social Aspects of HIV/AIDS, 7*(2), 51-61.

National AIDS Council. (2011). *Zimbabwe National HIV and AIDS Strategic Plan 2011-2015*. Retrieved from Harare, Zimbabwe:

Okal, J., Geibel, S., Muraguri, N., Musyoki, H., Tun, W., Broz, D., . . . Raymond, H. F. (2013). Estimates of the size of key populations at risk for HIV infection: men who have sex with men, female sex workers and injecting drug users in Nairobi, Kenya. *Sexually Transmitted Infections, 89*(5), 366-371. doi:10.1136/sextrans-2013-051071

R Core Team. (2015). *R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria*. Retrieved from http://www.R-project.org/

Sabin, K., Zhao, J., Garcia Calleja, J. M., Sheng, Y., Arias Garcia, S., Reinisch, A., & Komatsu, R. (2016). Availability and quality of size estimations of female sex workers, men who have sex with men, people who inject drugs and transgender women in low- and middle-income countries. *PLoS One, 11*(5), e0155150. doi:10.1371/journal.pone.0155150

UNAIDS. (2014). *90-90-90 An ambitious treatment target to help end the AIDS epidemic*. Retrieved from Geneva:

UNAIDS/WHO Working Group on Global HIV/AIDS and STI Surveillance. (2011). *Guidelines on Estimating the Size of Populations Most at Risk to HIV* (978 92 4 159958 0). Retrieved from Geenva:

Vandepitte, J., Lyerla, R., Dallabetta, G., Crabbe, F., Alary, M., & Buve, A. (2006). Estimates of the number of female sex workers in different regions of the world. *Sexually Transmitted Infections, 82*((Suppl III)), iii18-iii25.

Vojnov, L., & Scott, L. (2015). *Extending HIV Viral Load Testing: South African Experience* Paper presented at the 8th IAS Conference on HIV Pathogenesis, Treatment and Prevention Vancouver.

Volz, E., & Heckathorn, D. (2008). Probability Based Estimation Theory for Respondent Driven Sampling. *Journal of Official Statistics. 2008;24(1):79-97, 24*(1), 79-97.

Wesson, P., Reingold, A., & McFarland, W. (2017). Theoretical and empirical comparisons of methods to estimate the size of hard-to-reach populations: A systematic review. *AIDS Behav, 21*(7), 2188-2206. doi:10.1007/s10461-017-1678-9

WHO. (2014). Consolidated guidelines on HIV prevention, diagnosis, treatment and care for key populations. Retrieved from http://www.who.int/hiv/pub/guidelines/keypopulations/en/

Wojcicki, J. M., & Malala, J. (2001). Condom use, power and HIV/AIDS risk: sex-workers bargain for survival in Hillbrow/Joubert Park/Berea, Johannesburg. *Soc Sci Med, 53*(1), 99-121.

World Health Organization. (2011). *Preventing HIV among sex workers in sub-Saharan Africa: A literature review*. Retrieved from Geneva: