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1 **The HIV care cascade among female sex workers in Zimbabwe:**
 2 **results of a population-based survey from the Sisters**
 3 **Antiretroviral therapy Programme for Prevention of HIV, an**
 4 **Integrated Response (SAPPH-IRe) Trial**

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56

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59 Aid and Swedish SIDA. A small amount of funding for survey work is from GIZ. USAID support
60 the cost of PSI Zimbabwe to provide ART and PrEP to sex workers as part of the trial. We have
61 received a donation of Truvada for PrEP use for the trial from Gilead.

62 **Abstract**

63 **Introduction:** Female sex workers (FSW) in sub-Saharan Africa have a higher prevalence of HIV
64 than other women of reproductive age. Social, legal, and structural barriers influence their
65 access to care. Little is known about the HIV diagnosis and care cascade in most countries in
66 southern Africa. We aimed to describe the HIV diagnosis and care cascade among FSW in
67 Zimbabwe.

68 **Methods:** We conducted cross-sectional respondent driven sampling (RDS) surveys of FSW in
69 14 sites across Zimbabwe as the baseline for a cluster-randomised controlled trial investigating
70 a combination HIV prevention and care package. We administered a questionnaire, tested
71 women for HIV and measured viral load. We report the mean, minimum and maximum RDS-2
72 weighted site values.

73 **Results:** The survey included 2,722 women, approximately 200 per site. The mean HIV
74 prevalence was 57.5% (42.8-79.2 site minimum and maximum). Of HIV positive women, 64.0%
75 (51.6-73.7) were aware of their status, 67.7% (53.4-84.1) of these reported taking ART and
76 77.8% (64.4-90.8) of these had HIV viral load <1000 copies/ml. Among all HIV positive women,
77 49.5% had a viral load < 1000 copies/ml.

78 **Conclusions:** While the majority of HIV positive women aware of their status are accessing
79 ART, 36.0% of HIV positive women are unaware of their status and 29.3% of all FSW have an
80 unsuppressed HIV viral load. Investigation and investment into models of testing, treatment
81 and care are necessary to reach UNAIDS 90:90:90 targets.

82

83 The trial is registered with the Pan African Clinical Trials Registry (PACTR201312000722390).

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86 (SAPPH-IRe) trial has been funded by UNFPA via Zimbabwe's Integrated Support Fund which
87 receives funds from DfID, Irish Aid and Swedish SIDA. A small amount of funding for survey
88 work is from GIZ. USAID support the cost of PSI Zimbabwe to provide ART and PrEP to sex
89 workers as part of the trial. We have received a donation of Truvada for PrEP use for the trial
90 from Gilead Sciences.

91 **Competing Interests**

92 Dr. Phillips reports personal fees from Gilead Sciences, personal fees from GSK Vaccines, and
93 having served on an advisory board for AbbVie, outside the submitted work.

94 Dr. Cambiano reports personal fees from Merck Sharp & Dohmed Limited, outside the
95 submitted work.

96 Other authors declare no competing interests.

97

98 **Author Contributions**

- 99 Frances Cowan is the principal investigator of the trial, oversees trial design and
100 implementation, data interpretation and writing of manuscript.
- 101 Calum Davey conducted data analysis, produced tables and figures, contributed to data
102 interpretation and contributed to drafting and finalising the paper.
- 103 Elizabeth Fearon conducted data analysis, produced tables and figures, contributed to data
104 interpretation and contributed to drafting and finalising the paper.
- 105 Phillis Mushati oversaw data collection, reviewed and approved the final manuscript.
- 106 Jeffrey Dirawo oversaw data management, reviewed and approved the final manuscript.
- 107 Valentina Cambiano contributed to planning the study, edited and approved the final
108 manuscript.
- 109 Sue Napierala Mavedzenge contributed to planning the trial, provided comments on and
110 approved the manuscript.
- 111 Dagmar Hanisch contributed to planning the study, reviewed and approved the final
112 manuscript.
- 113 Karin Hatzold contributed to planning the study, reviewed and approved the final manuscript.
- 114 Owen Mugurungi, Nyasha Masuka and Milton Chemhuru contributed to planning the study,
115 reviewed and approved the final manuscript.
- 116 Joanna Busza contributed to planning the study, reviewed and approved the final manuscript.
- 117 Andrew Phillips contributed to planning the study, edited and approved the final version.
- 118 James Hargreaves helped plan the analysis and contributed to drafting and finalising the
119 paper.
- 120
- 121 All authors have approved the final manuscript.

122 **Introduction**

123 In sub-Saharan Africa, female sex workers (FSW) have high HIV incidence and prevalence and
124 therefore are in particular need of good access to effective HIV testing, prevention and
125 treatment services[1]. However, FSW are a marginalised group, sex work is illegal in many
126 countries including Zimbabwe[2], and FSW are often stigmatised by communities and health
127 workers[3, 4]. Typically, FSW are also highly mobile[5]. Designing service delivery approaches
128 that meet the needs of this population is therefore complex but urgently needed.

129 There is currently little information about the HIV diagnosis and care cascade amongst FSW
130 with which to guide programming. Previous studies of FSW in sub-Saharan Africa indicate that
131 antiretroviral therapy (ART) can be provided to FSW[6] at costs comparable to that of provision
132 in the general population[7]. A recent systematic review and meta-analysis of antiretroviral
133 uptake, adherence and outcomes among FSW found that current ART use among HIV positive
134 FSW was 39% (95% CI 29-48%), but noted a concerning lack of published data available[8].
135 Another review of the provision of sexual and reproductive health services for FSW in Africa
136 found little emphasis among programmes on access to antiretroviral treatment and support
137 for adherence[9]. While there is some evidence to guide the design of HIV prevention
138 programmes for FSW in Africa, little is known about the best means to improve testing, access
139 and adherence to ART and effective use of pre-exposure prophylaxis[10, 11].

140 In 2009, in response to a situational analysis conducted among FSW by Zimbabwe's National
141 AIDS Council and partners[12], the 'Sisters with a Voice' programme was established in five
142 sites, and has since expanded to 36 sites covering all the provinces of Zimbabwe. Services
143 provided are based on guidance from the World Health Organisation[13] and include HIV
144 testing and counselling, sexual and reproductive health services, condom provision and health
145 education supported by trained peer educators and a programme of community mobilisation.
146 Results of a respondent driven sampling (RDS) survey conducted in three towns in 2011[14],
147 along with qualitative work[15], suggested that FSW in Zimbabwe were poorly engaged with
148 HIV prevention and care services.

149 In response to this finding, we launched the **Sisters Antiretroviral Programme for Prevention of**
150 **HIV – an Integrated Response (SAPPH-IRe)** trial, a cluster-randomised controlled trial
151 conducted in 14 sites around Zimbabwe (7 matched-pairs). The aim is to determine the
152 effectiveness and cost effectiveness of an enhanced community-based intervention to increase
153 uptake, retention and adherence to antiretroviral-based prevention and therapy among FSW.

154 Outcomes were assessed at a population level in all 14 communities among FSW recruited to
155 RDS surveys at baseline (December 2013), and will also be assessed at endline (April-May
156 2016).

157 Aiming to contribute to our scant knowledge of the HIV diagnosis and care cascade amongst
158 FSW in sub-Saharan Africa, this paper describes the HIV diagnosis and care cascade at 14 sites
159 around Zimbabwe at the baseline of the SAPPH-IRe trial. Data are presented on socio-
160 demographic characteristics, HIV prevalence, ART coverage, viral suppression and the
161 proportion of all FSW with unsuppressed HIV viral load: the primary endpoint for the SAPPH-
162 IRe trial.

163 **Methods**

164 **Study Population and Setting**

165 Fourteen of the 36 sites where the 'Sisters' services are provided are included in the SAPPH-
166 IRe trial. These sites were purposively selected to reflect different sex work location types (e.g.
167 town, growth point, colliery/army base), were locations of adequate size (85-300 FSW
168 attending clinics annually) and were geographically disparate to minimise contamination
169 during the trial.

170 **Data Collection**

171 We conducted respondent driven sampling (RDS)[16] surveys of FSW using identical
172 procedures in each of the 14 sites. We used RDS because it was unfeasible to assemble a
173 sampling frame of the intended target population; it has been recommended for research
174 amongst hard-to-reach populations[17]; we successfully conducted similar RDS surveys of FSW
175 in 3 locations in 2011[14], and sex work in these settings is not conducted primarily within
176 brothels or set venues making time-location sampling methods less appropriate. Women were
177 eligible if they were aged 18 or over; had exchanged in sex for money or gifts in the preceding
178 30 days, and had lived at the site for at least the previous six months. In each site we first
179 conducted 2-3 days of geographic and social mapping, including informal discussions with
180 trained peer educators, healthcare staff, and community informants. This formative work
181 informed specific criteria for purposely selected "seed" women to ensure that all sub-
182 populations within the site's sex worker population were represented and helped determine
183 how many of these seeds should be selected[18].

184 In line with RDS methodology, seed participants in each site were interviewed and given two
185 recruitment coupons to pass on to their sex worker peers. Women were uniformly advised to
186 recruit other sex workers whose name they knew and who knew their name, who had not
187 already enrolled in the study and who met the study eligibility criteria. Interviewers used
188 screening questions to confirm as far as possible that women given coupons met these criteria
189 when they presented for interview. Six seeds were recruited in the smaller sites, while in four
190 larger sites eight seeds were recruited. When women receiving the coupons attended for the
191 interview ("recruits") they were also given two coupons to give out to women they knew who
192 worked as FSW in that location. Coupons were coded such that recruiter/recruitee
193 relationships could be tracked and unique IDs recorded. In all 14 sites a maximum of five
194 iterations, or 'waves', of this process were performed (6 waves, including the initial seeds). We

195 aimed to recruit 200 FSW per site to give adequate power to detect the intervention effect at
196 follow-up[19]. In line with other RDS surveys, women were reimbursed for participating in the
197 survey (\$5) and for recruiting eligible participants (\$2 for each recruited). All participants gave
198 informed consent to participate after receiving information about the study from trained
199 interviewers and being given the opportunity to ask questions.

200 Five teams of trained researchers undertook data collection between 13 November and 20
201 December 2013. Interviewer-administered questionnaire data was collected onto tablet
202 computers and directly loaded into a master database using a wireless internet connection in
203 the field. Questionnaires included information on demographics, sex work, sexual behaviour
204 and condom use, HIV testing history, ART use, stigma, experience of violence, relationships
205 with other sex workers, and use of sexual and reproductive health services. We also collected
206 data to determine personal network size, or 'degree', for RDS estimation. In our survey, the
207 degree was the number of FSW a participant reported knowing personally, whose name they
208 knew and who knew theirs, who were at least 18 years old, lived at the site, and whom the
209 participant would consider recruiting to the study.

210 All women had a finger prick blood sample collected in the form of a dried blood spot (DBS) for
211 detection of HIV antibody (AniLabsystems EIA kit (AniLabsystems Ltd, OyToilette 3, FIN-01720,
212 Finland)). Blood samples were air-dried on filter papers and stored at room temperature, then
213 transported biweekly to the Flowcytometry Laboratory in Harare. If HIV antibodies were
214 detected then the DBS sample was tested for HIV viral load using NucliSENS EasyQ HIV-1 v2.0,
215 both to confirm HIV positive status and to quantify the viral load. For samples with a positive
216 HIV antibody test, but an undetectable viral load, a second confirmatory ELISA was performed
217 (Enzygnost Anti-HIV 1/2 Plus ELISA (Germany)). At two trial sites, plasma samples were
218 collected in addition to DBS and tested in parallel using NucliSENS EasyQ HIV-1 v2.0, to permit
219 validation of the use of DBS for viral load quantification [20].

220 The Medical Research Council Zimbabwe, University College London, and the London School of
221 Hygiene and Tropical Medicine gave ethical approval for the SAPPH-IRe trial, including the
222 baseline data collection and analysis. The trial was also registered with the Research Council of
223 Zimbabwe, the Pan African Clinical Trials Registry (PACTR201312000722390) and was
224 approved by the Medicines Control Authority of Zimbabwe.

225 **Data analysis**

226 We follow the recommendations of the STROBE-RDS guidelines in reporting our study[21].
227 First, we described the sample recruited. A limitation of RDS is that it is difficult to describe
228 non-participation rates since no sample frame is present, and we did not conduct ‘exit
229 interviews’ of women who had distributed coupons to ascertain how many of their peers
230 refused to take part. We calculated cluster-summaries for key socio-demographic
231 characteristics of the sample. We calculated and report the mean of the 14 cluster-level RDS-2
232 weighted summaries and the range of estimates across clusters (minimum and maximum).
233 Both as a total and summarised across clusters, we described the proportion of participants
234 with suppressed HIV viral load, (<1000 copies/ml, as per WHO guidelines[22, 23]), and steps of
235 the HIV care cascade underlying this: the proportion who were found to be HIV positive; the
236 proportion who reported via questionnaire previously testing positive (i.e. knew their status);
237 the proportion who reported being on ART, and the proportion who had a viral load of <1000
238 copies/ml. We described these estimates both as proportions of the previous step on the
239 cascade and as proportions of the total of women testing HIV positive.

240 We used ‘RDS-2’ to conduct all analyses, which uses the ‘Volz-Heckathorn’ estimator[24] and
241 has been found to be less biased than previous estimators[25]. RDS-2 is based on estimating
242 the inclusion probabilities of each survey participant, assuming the recruitment process can be
243 modelled as a ‘random walk’ over the social network of FSW. Within this model, the
244 probability that each participant will be included is approximated as the inverse of the
245 reported degree. Estimates were calculated in Stata 12 using the ‘rds’ analysis package[26],
246 which removes seeds from the proportion estimates.

247 RDS-2 estimation assumes that recruitment chains progress such that final estimates are no
248 longer dependent on the characteristics of the seeds, that recruitment does not become
249 confined within sub-groups of the FSW population (‘bottlenecks’), and assumes with-
250 replacement sampling even when women cannot participate more than once in practice[25].
251 We assessed these assumptions and their potential for bias on estimates of HIV prevalence
252 and suppressed viral load for each site, using plots of the convergence of HIV and viral
253 suppression estimates over sample waves (‘convergence plots’) and plots of estimate
254 convergence by seed (‘bottleneck plots’). We also examined the difference between RDS-2
255 estimates and estimates produced using the RDS ‘successive sampling’ estimator[27] for a
256 range of possible population sizes to assess the bias resulting from assuming with-replacement

257 sampling. These analyses were guided by published advice about RDS diagnostics[28] and used
258 the 'rds' package for the R statistical language[29]. Details of the diagnostic methods and
259 results are given in Appendix 1.

260 **Results**

261 **RDS recruitment and estimation**

262 In total 2,722 participants were recruited over six waves in 14 sites. Of these participants, 90
263 were seeds, of whom 62 (68.9%) were HIV positive and 29 (32.2%) had HIV viral load \geq 1000
264 copies/ml. The number of non-seed “recruits” varied from 147 to 212 per site. There were an
265 additional 15 participants from 8 sites who were missing recruiter information and who were
266 treated as seeds and therefore dropped from the estimation.

267 Estimates for the proportion of FSW with suppressed viral load and for HIV prevalence
268 appeared to converge well by the final sample wave for all sites except one for HIV prevalence
269 and two for viral load, and there was little evidence of recruitment becoming confined within
270 sub-groups from any site (see Appendix 1).

271 **Characteristics of female sex workers**

272 Participants were aged between 18 and 65, with a mean age of 31 years (minimum site mean
273 of 29 and maximum of 34). Approximately one third of women had no or only primary
274 education, another third had completed Forms 1-3 and the final third had completed at least
275 Form 4 (see Table 1). Very few of the women were married (0.8% overall unweighted, the
276 proportion was too small to calculate RDS weights) and 61.9% (range 46.4-70.6% across sites)
277 were separated or divorced. The majority of women (53.5%) reported initiating sex work by 24
278 years old, with 17.4% (8.5 – 25.9) reporting having started sex work before they were 18 years
279 old. In total 8.2% reported having no clients in the past week, 49.9% of women reported
280 having between 1 and 5 clients per week; and 13.2% reported having 16 or more. Just under
281 half of the women in each cluster (45.0%) were food insecure (food insecurity was indicated by
282 any of the following: being unable to eat two meals a day; sometimes going to bed hungry;
283 going an entire day without eating in the last week). More than a quarter of women (26.7%)
284 had worked at another geographic location in the previous 12 months, while 52.2% had lived
285 in their current location for six or more years. 61.4% of the women reported good or very good
286 relations with other FSW.

287 Violence from intimate partners was the most common form of interpersonal violence ever
288 experienced (40.3%), followed by violence from clients (27.7%). Violence from police in the
289 previous year was 9.7% overall, though in one location it was 19.5%.

290

291 The majority of participants reported having previously tested for HIV (91.1%), and of those
292 who were HIV negative 70.5% (52.7-88.8) reported having tested for HIV in the previous six
293 months.

294 **HIV and the diagnosis and care cascade**

295 The HIV care cascade for HIV positive FSW is described in Figure 1. HIV prevalence amongst
296 FSW was estimated to be 57.5%, ranging from 42.8% to 79.2% across sites.

297 Among those who tested HIV positive, an average of 64.0% (51.6 – 73.7) in each site were
298 aware of their status, i.e. they reported a previous positive HIV test. Of those aware of their
299 positive status, 67.7% (53.4 – 84.1) reported taking ART, which was 43.3% (32.3 – 54.0) of all
300 those who tested HIV positive in the study. Across sites, an average of 77.8% (64.4 – 90.8) of
301 women who were on ART had a viral load < 1000 copies/ml. Women on ART with viral loads
302 <1000 copies/mL were 33.7% (range 36.5 – 62.2) of all those testing HIV positive. An additional
303 15.8% (range 12.6 – 16.6) of those testing positive had a viral load <1,000 copies/ml, despite
304 not reporting being on ART. Of all HIV positive FSW, 43.3% (32.3 – 54.0) were on ART and
305 49.5% (36.5-62.2) had viral loads of <1000 copies/mL.

306 When considering all FSW as the denominator, there were an estimated 29.3% (18.9-42.3) of
307 women who had an unsuppressed HIV viral load of \geq 1000 copies/mL.

308

309 **Discussion**

310 We analysed data from 2,722 FSW recruited in 14 sites in Zimbabwe. HIV prevalence was very
311 high (mean 57.5% across sites, ranging 42.8-79.2%). While recent HIV testing and access to
312 ART were relatively common, still some 36.0% of HIV positive FSW did not report that they
313 were positive in the research interview (26.3-48.4). The majority of women who tested HIV
314 positive and reported being aware of their status reported accessing ART (67.7%) and of those,
315 77.8% had a viral load <1000 copies/ml. However, overall only 49.5% of all HIV positive women
316 had a viral load <1000 copies/ml, in part because many were unaware of their status.
317 Significant and rapid progress is needed to reduce HIV infection rates, increase HIV status
318 awareness and improve overall levels of viral suppression.

319 We undertook an ambitious field study to collect baseline data and test the feasibility of our
320 proposed approach to the trial endline data collection. We have shown that it was feasible to
321 rapidly recruit approximately 200 FSW per site in 14 sites across Zimbabwe using RDS
322 methodology. Our findings make an important contribution to the sparse literature on the HIV
323 diagnosis and care cascade among FSW in sub-Saharan Africa[8]. We have been able to
324 measure women having unsuppressed viral load as a proportion of all HIV positive sex
325 workers, not only among those accessing ART, which is important given that approximately
326 one third of HIV positive FSW were unaware of their status. Sampling approaches such as ours
327 provide a key means for assessing how close we are to the 90:90:90 targets[30] in a given
328 population or setting.

329 All sampling methods for hard-to-reach populations have limitations, and RDS is no exception.
330 The estimation makes many assumptions about the recruitment process and the social
331 networks of sex workers. Appropriate statistical techniques should be used though there
332 remains debate about methods of analysis. We present diagnostics in Appendix 1. However, as
333 in all applications of RDS in hidden populations it was not possible for us to empirically verify
334 the extent to which the sample we recruited reflects the characteristics of FSWs working in the
335 14 sites. A major strength of our study was that we adopted identical field procedures in each
336 of the sites, strengthening our capacity to compare findings across them.

337 Our estimate of viral load for HIV positive FSW was based on analysis of dried blood spot
338 samples. While plasma analysis is normally considered the gold-standard approach, DBS
339 appeared to be an acceptable method for viral load monitoring using the NucliSENS assay, and

340 we estimated high DBS sensitivity compared to plasma 'gold-standard' (sensitivity=87.4% and
341 specificity=96.8%)[20].

342 Coverage of ART among HIV positive FSW was similar at 43.4% (range 32.3 – 54.0) to the 40%
343 we had hypothesised prior to the trial[19]. This was slightly higher but in the range of the
344 pooled estimate of 39.3% (27.2-52.9%) among sex workers from low and middle income in
345 studies found in a recent meta-analysis and systematic review[8]. Some 67.7% of those FSW
346 who were aware of their status and reported they were positive also reported taking ART
347 (range 53.4-84.1%). This was similar to our findings in three sites in 2011, when we found 51-
348 74% HIV positive FSWs who were aware of their HIV status were also engaged with care[14].
349 However, coverage is well below the 90:90:90 target set by UNAIDS[30]. Coverage among the
350 general population of adult women in Zimbabwe is not known.

351 Overall 77.8% of those reporting taking ART had a viral load <1000 copies/ml, as did 15.8% of
352 HIV positive women who did not report being on ART. That such a large proportion of women
353 not on ART had a suppressed viral load was not anticipated; one explanation is that women
354 under-reported their knowledge of HIV status and ART usage. However, there have been other
355 surveys with similar findings: the 2012 Kenya AIDS Indicator Survey found that 30% of
356 individuals who reported not being on ART were virally suppressed[31] and among men who
357 have sex with men in the United States reporting to be unaware of their status and therefore
358 not on ART in 2004-2011, 2/11 to 3/7 were found to be virally suppressed[32]. We plan to
359 investigate this further.

360 **Conclusions**

361 In conclusion, our findings have contributed to knowledge of the HIV care cascade among sex
362 workers in southern Africa. They confirm the urgent need for HIV prevention and care services
363 in this population. We hope that the SAPPH-Ire trial will contribute to our understanding of
364 how best to serve the needs of female sex workers in the region.

365

366 **References**

- 367 1. Baral S, Beyrer C, Muessig K, Poteat T, Wirtz AL, Decker MR, *et al.* Burden of HIV
368 among female sex workers in low-income and middle-income countries: a systematic
369 review and meta-analysis. *Lancet Infect Dis* 2012,**12**:538-549.
- 370 2. Gruskin S, Ferguson L, Alfvén T, Rugg D, Peersman G. Identifying structural barriers to
371 an effective HIV response: using the National Composite Policy Index data to evaluate
372 the human rights, legal and policy environment. *J Int AIDS Soc* 2013,**16**:18000.
- 373 3. Pulerwitz J, Bongaarts J. Tackling stigma: fundamental to an AIDS-free future. *Lancet*
374 *Glob Health* 2014,**2**:e311-312.
- 375 4. Scambler G, Paoli F. Health work, female sex workers and HIV/AIDS: global and local
376 dimensions of stigma and deviance as barriers to effective interventions. *Soc Sci Med*
377 2008,**66**:1848-1862.
- 378 5. Ramesh S, Ganju D, Mahapatra B, Mishra RM, Saggurti N. Relationship between
379 mobility, violence and HIV/STI among female sex workers in Andhra Pradesh, India.
380 *BMC Public Health* 2012,**12**:764.
- 381 6. Huet C, Ouedraogo A, Konate I, Traore I, Rouet F, Kabore A, *et al.* Long-term
382 virological, immunological and mortality outcomes in a cohort of HIV-infected female
383 sex workers treated with highly active antiretroviral therapy in Africa. *BMC Public*
384 *Health* 2011,**11**:700.
- 385 7. Cianci F, Sweeney S, Konate I, Nagot N, Low A, Mayaud P, *et al.* The cost of providing
386 combined prevention and treatment services, including ART, to female sex workers in
387 Burkina Faso. *PLoS One* 2014,**9**:e100107.
- 388 8. Mountain E, Mishra S, Vickerman P, Pickles M, Gilks C, Boily MC. Antiretroviral therapy
389 uptake, attrition, adherence and outcomes among HIV-infected female sex workers: a
390 systematic review and meta-analysis. *PLoS One* 2014,**9**:e105645.
- 391 9. Dhana A, Luchters S, Moore L, Lafort Y, Roy A, Scorgie F, *et al.* Systematic review of
392 facility-based sexual and reproductive health services for female sex workers in Africa.
393 *Global Health* 2014,**10**:46.
- 394 10. Chersich MF, Luchters S, Ntaganira I, Gerbase A, Lo YR, Scorgie F, *et al.* Priority
395 interventions to reduce HIV transmission in sex work settings in sub-Saharan Africa
396 and delivery of these services. *J Int AIDS Soc* 2013,**16**:17980.
- 397 11. WHO. Consolidated guidelines on HIV prevention, diagnosis, treatment and care for
398 key populations. Geneva: World Health Organization; 2014.

- 399 12. Sex Work and HIV and AIDS in Zimbabwe: Analysis of current settings, policies and
400 interventions. In: National AIDS Council, International Organization for Migration, Joint
401 United Nations Team on HIV and AIDS, United Nations Population Fund; 2008.
- 402 13. WHO. Prevention and Treatment of HIV and other Sexually Transmitted Infections for
403 Sex Workers in Low- and Middle-income Countries: Recommendations for a public
404 health approach. Geneva: World Health Organization; 2012.
- 405 14. Cowan FM, Mtetwa S, Davey C, Fearon E, Dirawo J, Wong-Gruenwald R, *et al.*
406 Engagement with HIV prevention treatment and care among female sex workers in
407 Zimbabwe: a respondent driven sampling survey. *PLoS One* 2013,**8**:e77080.
- 408 15. Mtetwa S, Busza J, Chidiya S, Mungofa S, Cowan F. "You are wasting our drugs": health
409 service barriers to HIV treatment for sex workers in Zimbabwe. *BMC Public Health*
410 2013,**13**:698.
- 411 16. Heckathorn D. Respondent-driven sampling: a new approach to the study of hidden
412 populations. *Social Problems* 1997,**44**:174-199.
- 413 17. Sabin KM, Johnston LG. Epidemiological challenges to the assessment of HIV burdens
414 among key populations: respondent-driven sampling, time-location sampling and
415 demographic and health surveys. *Curr Opin HIV AIDS* 2014,**9**:101-106.
- 416 18. Johnston LG, Whitehead S, Simic-Lawson M, Kendall C. Formative research to optimize
417 respondent-driven sampling surveys among hard-to-reach populations in HIV
418 behavioral and biological surveillance: lessons learned from four case studies. *AIDS*
419 *Care* 2010,**22**:784-792.
- 420 19. Cowan F. Antiretrovirals for HIV prevention and treatment among Zimbabwean sex
421 workers. *Trial protocol*. Available on request; 2013.
- 422 20. Mavedzenge SN, Davey C, Chirenje T, Mushati P, Mtetwa S, Dirawo J, *et al.* Finger Prick
423 Dried Blood Spots for HIV Viral Load Measurement in Field Conditions in Zimbabwe.
424 *PLoS One* 2015,**10**:e0126878.
- 425 21. White RG, Hakim AJ, Salganik MJ, Spiller MW, Johnston LG, Kerr L, *et al.* Strengthening
426 the Reporting of Observational Studies in Epidemiology for respondent-driven
427 sampling studies: "STROBE-RDS" statement. *J Clin Epidemiol* 2015.
- 428 22. WHO. Consolidated guidelines on the use of antiretroviral drugs for treating and
429 preventing HIV infection: recommendations for a public health approach. Geneva:
430 World Health Organization; 2013.

- 431 23. WHO. Consolidated strategic information guidelines for HIV in the health sector.
432 Geneva: World Health Organization; 2015.
- 433 24. Volz E, Heckathorn DD. Probability Based Estimation Theory for Respondent Driven
434 Sampling. *Journal of Official Statistics* 2008,**24**:79-97.
- 435 25. Gile KJ, Handcock MS. Respondent-Driven Sampling: An Assessment of Current
436 Methodology. *Sociol Methodol* 2010,**40**:285-327.
- 437 26. Schonlau M, Liebau E. Respondent-driven sampling. *Stata Journal* 2012,**12**:72-93.
- 438 27. Gile KJ. Improved Inference for Respondent-Driven Sampling Data With Application to
439 HIV Prevalence Estimation. *Journal of the American Statistical Association*
440 2011,**106**:135-146.
- 441 28. Gile KJ, Johnson LG, Salganik MJ. Diagnostics for respondent driven sampling. *Journal*
442 *of the Royal Statistical Society: Series A* 2014.
- 443 29. Handcock MS, Fellows IE, Gile KJ. RDS: respondent-driven sampling, Version 0.6. In;
444 2012. pp. Project home page at <http://hpmrg.org>, URL [http://CRAN.R-](http://CRAN.R-project.org/package=RDS)
445 [project.org/package=RDS](http://CRAN.R-project.org/package=RDS).
- 446 30. UNAIDS. 90-90-90: An ambitious treatment target to help end the AIDS epidemic. In.
447 Geneva: UNAIDS; 2014.
- 448 31. Wafula R, Masyuko S, Ng'ang'a L, Kim AA, Gichangi A, Mukui I, *et al*. Engagement in HIV
449 care among Kenyan adults and adolescents: results from a national population-based
450 survey. *J Acquir Immune Defic Syndr* 2014,**66 Suppl 1**:S98-105.
- 451 32. Das M, Raymond HF, Chu P, Nieves-Rivera I, Pandori M, Louie B, *et al*. Measuring the
452 unknown: calculating community viral load among HIV-infected MSM unaware of their
453 HIV status in San Francisco from National HIV Behavioral Surveillance, 2004-2011. *J*
454 *Acquir Immune Defic Syndr* 2013,**63**:e84-86.

455 **Figure legend**

456 **Figure 1:** *The y-axis indicates the proportion of women at each step of the cascade of all*
457 *women testing HIV positive, while the figures on each bar indicate the proportion of women*
458 *from each preceding step. Bars indicate the mean RDS weighted values across sites, while the*
459 *coloured points are individual site values. The shaded portion of the virally suppressed bar*
460 *represents those women who had a suppressed viral load, but who did not report taking ART.*

461

462 **Supplemental Digital Content**

463 Additional File 1, *Appendix 1. RDS Diagnostics*. This is a MS Word “.docx” file that describes
464 and reports on recommended diagnostic procedures carried out to test assumptions made by
465 the Respondent Driven Sampling (RDS) method.