Systematic review and meta-analysis of community and facility-based HIV testing to address linkage to care gaps in sub-Saharan Africa

Monisha Sharma¹, Roger Ying², Gillian Tarr¹ & Ruanne Barnabas¹,²,³,⁴

HIV testing and counselling is the first crucial step for linkage to HIV treatment and prevention. However, despite high HIV burden in sub-Saharan Africa, testing coverage is low, particularly among young adults and men. Community-based HTC (conducted outside of health facilities) has the potential to reduce coverage gaps, but the relative impact of different modalities is not well assessed. We conducted a systematic review of HIV testing modalities, characterizing community (home, mobile, index, key populations, campaign, workplace and self-testing) and facility approaches by population reached. HIV positivity, CD4 count at diagnosis and linkage. Of 2,520 abstracts screened, 126 met eligibility criteria. Community HIV testing and counselling had high coverage and uptake and identified HIV-positive people at higher CD4 counts than facility testing. Mobile HIV testing reached the highest proportion of men of all modalities examined (50%, 95% confidence interval (CI) = 47–54%) and home with self-testing reached the highest proportion of young people (66%, 95% CI = 56–67%). Few studies evaluated HIV testing for key populations (commercial sex workers and men who have sex with men), but these interventions yielded high HIV positivity (38%, 95% CI = 19–62%) combined with the highest proportion of first-time testers (78%, 95% CI = 63–88%), indicating service gaps. Community testing with facilitated linkage (for example, counsellor follow-up to support linkage) achieved high linkage to care (95%, 95% CI = 87–98%) and antiretroviral initiation (75%, 95% CI = 68–82%). Expanding home and mobile testing, self-testing and outreach to key populations with facilitated linkage can increase the proportion of men, young adults and high-risk individuals linked to HIV treatment and prevention, and decrease HIV burden.

Globally, there are around 2.3 million new HIV infections annually, 80% of which occur in sub-Saharan Africa. Despite the high burden, only one-third of adults in sub-Saharan Africa have been tested for HIV in the past year and less than 50% of HIV-positive individuals know their status. Knowledge of one’s serostatus is vital for accessing lifesaving antiretroviral therapy (ART) and linking to HIV prevention. Conventional facility-based HIV testing and counselling (HTC) has not achieved high testing coverage in sub-Saharan Africa and will probably be insufficient to meet UNAIDS ambitious 90–90–90 targets — 90% of HIV-positive people knowing their status, 90% of HIV-positive people who are aware of their status on ART, and 90% of people on ART virally suppressed. Barriers to facility testing include distance from clinic, long wait times, costs (transportation, lost wages and childcare), confidentiality concerns, low perceived risk and infrequent contact with the health-care system. In addition, patients often present at facilities late in the course of their illness, increasing HIV morbidity, mortality and transmission. Community-based HTC (conducted outside of a health facility) has the potential to overcome these barriers, achieve high coverage, and identify asymptomatic HIV-positive individuals at high CD4 counts. In addition, community HTC may reach more men, young adults, and key populations than facility HTC. Community-based strategies also require minimal infrastructure allowing for easier scale up. Community HTC modalities include: home, mobile, workplace, index partner/family members (sexual partners or family members of HIV-positive individuals) and as part of a campaign. Uptake and demographics of populations reached can vary widely by modality. A large number of studies on HTC have been conducted in sub-Saharan Africa and a previous systematic review was completed in 2012, but facility testing was not included and uptake in men and young adults was not assessed. In addition, several large-scale interventions have been published since 2012 (refs 11, 13–15). Recently, the World Health Organization released guidelines that strongly recommend implementing community HTC. As most countries have multiple and varying epidemics, UNAIDS recommends creating regional policies tailored to the macroepidemic rather than nationwide approaches. Local policymakers will need to determine the optimal combination of community HTC interventions to increase testing in the context of their country’s HIV epidemic.

To provide evidence for decision makers, we summarize the literature on community and facility-based HTC. We characterize each modality by population coverage, since high coverage is beneficial to both HIV-positive and -negative people. HTC can reduce risk behaviour in HIV-negative individuals, while providing a means to link them to primary prevention (including circumcision and pre-exposure prophylaxis (PrEP)). We evaluate effectiveness in reaching men and young adults (both groups have low HIV testing and poorer clinical outcomes).
Figure 1: Pooled coverage and uptake of HIV testing and counselling (HTC) modalities. Coverage is defined as total number of people tested/total number of people in the target population. Uptake is defined as total number of people tested/total number of people offered testing. Bars indicate 95% confidence intervals of random effects meta-analyses. N, sample size; PITC, provider-initiated testing and counselling; VCT, voluntary counselling and testing.

outcomes once infected\textsuperscript{22–24} and targeted HTC for key populations (men who have sex with men (MSM), commercial sex workers (CSWs) and people who inject drugs (PWID)) — groups that generally have very high HIV prevalence and low access to health care\textsuperscript{11}. We assess HIV positivity to characterize yield and examine CD4 count at diagnosis to identify modalities that have the potential to link infected individuals to care earlier in their disease course. Estimates from our analysis can also be used as parameters in mathematical models to project the long-term impact of HTC interventions.

**METHODS**

**Inclusion criteria.** We conducted a systematic literature review following Cochrane and PRISMA (preferred reporting items for systematic reviews and meta-analyses) guidelines\textsuperscript{26}. Studies were eligible for inclusion if they reported data on at least one of the following outcomes: coverage (individuals who accepted HTC/eligible target population); uptake (individuals who accepted HTC/individuals offered HTC); proportion of young adults (either under 25 or under 30 years); proportion of men; proportion of first-time testers; HIV positivity (number positive/total tested); proportion with a CD4 count of 350 cells \( \mu l^{-1} \) or less; proportion linked to care (those who had visited a clinic, obtained a CD4 count or initiated ART); proportion retained in care (individuals retained/individuals who initiated ART); or cost per person tested. The target population was defined as the eligible population in the catchment area, either enumerated by the study (often the case for home HTC) or estimated (often the case for mobile and campaign HTC). For facility HTC, the target population was defined as people visiting the clinic, and for index partner or family members it was defined as all sexual partners or cohabitating family members listed by the index patient. With the exception of HTC targeted to key populations, we excluded HTC studies not related to general population screening, including case reports and studies limited to antenatal or paediatric settings, or to patients with specific diseases (for example, tuberculosis). Observational (cross-sectional and cohort) studies and randomized trials were eligible for inclusion. Studies were included in the analyses more than once if they had different arms or multiple study sites (for example, urban and rural settings or different countries). If more than one wave of a survey or intervention was completed, only the most recent was used.

**Search strategy.** Literature searches were conducted with the help of a librarian on 22 July 2014 and updated on 10 June, 2015. Briefly, we searched PubMed, EMBASE, Cochrane Library, Global Health Database, African Index Medicus, and conference abstracts (CROI, R4P, IAS) using MeSH terms for PubMed and comparable terms for other databases. Search terms included “HIV infections/diagnosis” AND “Africa South of the Sahara” AND (“mass screening” OR test OR tests OR testing OR screen* OR diagnosis OR “counseling”). Bibliographies of relevant papers were screened and authors were contacted for missing outcomes. Searches were limited to human studies published between 2000 and 2015. The full strategy is described in the Supplementary Information.

**Definitions of HTC modalities.** Community-based HTC was defined as testing conducted outside of health facilities. Facility-based HTC was conducted in health-care facilities (clinics, hospitals, fixed stand-alone voluntary counselling and testing sites). Facility HTC was divided into two categories: voluntary counselling and testing (VCT), which is patient-initiated testing and provider-initiated testing and counselling (PITC), which is routine; or opt-out HTC that is initiated by a provider. Community HTC modalities included home (offering HTC door-to-door to a catchment area), mobile (setting up a mobile van or container to provide HTC in a central area of a community), index partner or family member (offering HTC to individuals who may have been exposed to HIV by a sexual partner or who have an HIV-positive household member), campaign (short — generally 1 to 2 weeks — intensive community mobilization followed by mobile testing, often partnered with other health interventions), key populations (targeted to MSM, CSWs and PWID) and workplace (offered at a place of employment). We examined a subset of home and workplace HTC that used self-testing.

**Data screening and extraction.** M.S., R.Y. and R.V.B. screened abstracts for initial inclusion. Disagreements were adjudicated by reviewing the full text. M.S., R.V.B., R.Y. and G.T. reviewed papers for eligibility and used a standardized extraction form to characterize eligible studies (Supplementary Information 2). Study quality was rated low, moderate or high based on representativeness of underlying population, follow-up (present or absent), assessment of outcomes, and number of outcomes presented. Costs were inflated to 2012 US dollars by converting to local currency units, multiplying by the ratio of each country’s gross domestic product deflator (2012 deflator divided by base year deflator) and converting back to US dollars\textsuperscript{27}.

**Statistical analysis.** Random effects meta-analysis of single proportions with binomial exact confidence intervals (CI) was used to summarize results. Proportions were stabilized using the Freeman–Tukey double arcsine transformation unless the number of events was less than ten, in which case a logit
transformation was used because of convergence issues. Heterogeneity was quantified using the I² statistic. For modalities with enough data (ten studies or more), trends were examined by year before 2005 (when the HIV rapid diagnostic test was introduced), country and facilitated linkage. Analyses were conducted in R software using the metaprop function in the meta package.

RESULTS

We identified 126 eligible studies out of 2,520 abstracts (Supplementary Figure S0.a). Overall, 64% of studies were rated moderate or high quality (Supplementary Information 2). Most studies included in our analysis evaluated facility and home HTC. We identified far fewer studies on other types of community HTC: home with self-testing (n = 2), workplace with self-testing (n = 2), index partner/family member (n = 5), key populations (n = 5), campaign (n = 5) and workplace (n = 4). Forest plots of each outcome by modality are provided in the Supplementary Information with pooled estimates presented here. I² values of pooled estimates varied from 90% to 100%, reflecting high heterogeneity in study designs and countries included (Supplementary Information). The countries represented varied by outcome with the greatest number of countries having data for home and facility HTC coverage, uptake and test-and-counsel demographics. Far fewer studies reported CD4 count at diagnosis and linkage to care outcomes; studies containing these data were mainly conducted in South Africa, Kenya and Uganda. All home self-testing studies were conducted in Malawi and the most key population studies were conducted in Nigeria. Overall, the largest number of studies were conducted in South Africa.

Coverage and uptake

Coverage was reported in 19 home HTC studies, 4 index partner/family member, 5 facility VCT, and 5 facility PITC studies. Overall, community HTC modalities achieved higher coverage than facility, with home (70%, 95% CI = 58–79) and campaign (76%, 95% CI = 49–95) having the highest population coverage (Fig. 1). Home HTC consistently achieved high coverage across 19 studies, whereas campaign coverage was also high, but based on only two studies. Pooled coverage was 37% (95%, CI = 33–42%) for mobile HTC, from 1 study conducted in 3 countries (South Africa, Tanzania and Zimbabwe). Coverage of index HTC was heterogeneous depending on target group (family members or sexual partners) and type of contact tracing (active or passive referral). Figure 1 shows results for sexual partner tracing only (41%); full results are shown in Supplementary Figure S1B. Facility VCT (15%, 95% CI = 9–21%) and PITC (18%, 95% CI = 18–31%) attained the lowest coverage.

Uptake was reported in 31 home HTC studies, 2 home with self-testing, 2 mobile, 3 index partner or family member, 4 campaigns, 3 workplace, 3 facility VCT, and 11 facility PITC studies. Overall, community modalities had high uptake (Fig. 1). Home HTC had a pooled uptake of 82% (95% CI = 76–87%) and home with self-testing had slightly lower uptake (69%, 95% CI = 59–78). Mobile and campaign had the highest uptake (both 97%). Index partner uptake was 89% (95% CI = 88–90%) for home testing of family members (Supplementary Figure S10) and 52% for sexual partners (95% CI = 30–71%; Fig. 1). Uptake for facility VCT was defined as number tested divided by number offered for VCT by provider, for facility PITC it was defined as number tested divided by number offered PITC. We found higher uptake for people given routine PITC (73%, 95% CI = 55–87%) compared with those referred to on site VCT (26%, 95% CI = 15–39%).

Demographics of testers

The percentage of men out of tot al persons tested was reported in 25 home HTC studies, 31, 1 mobile, 2 campaign, 3 index partner/family member, 5 facility VCT, and 10 facility PITC studies. Overall, community HTC modalities had the highest percentage of men (50%, 95% CI = 47–54%), whereas home had the lowest for general population HTC (40%, 95% CI = 39–41%). Index partner testing had 41% men (95% CI = 23–61%), but varied greatly by tracing strategy; active tracing had 50% men whereas passive clinic referral had only 15% (Supplementary Figure S1B). Facility VCT and PITC both had 42% men.

Percentage of participants reporting testing for the first time was included in 20 home HTC studies, 30, 1 mobile, 2 campaign, 3 index partner/family member, 5 facility VCT, and 10 facility PITC studies. Pooled percentages of first-time testers were higher for community than facility modalities (Fig. 2). Percentages varied by country, with South Africa consistently having the lowest percentage of first-time testers across modalities (Supplementary Figures S23–S27). Key population interventions had the highest proportion of first-time testers (83%, 95% CI = 71–91%), and mobile had the highest percentage among the general population (63%, 95% CI = 50–74%). Home HTC had 58% first-time testers (95% CI = 48–67%), and campaign had 55% (95% CI = 20–91%), but was highly variable depending on the setting (Supplementary Figure S25). Facility VCT had 53% (95% CI = 54–56).
HIV testing and linkage | Sharma et al.

Figure 3 | Pooled HIV positivity and proportion of newly diagnosed HIV positivity with CD4 count of 350 cells ml⁻¹ or less by HIV testing and counselling (HTC) modality. Bars indicate 95% confidence intervals of random effects meta-analyses. N, sample size. CSWs, commercial sex workers; MSM, men who have sex with men; PITC, provider-initiated testing and counselling; PWID, people who inject drugs; VCT, voluntary counselling and testing.

40–66%) and PITC had 55% (95% CI = 48–62%) first-time testers. The percentage of young adults testers (either under 25 or 30 years) was reported in 17 home HTC studies 10,13,68,72,92–95,97,98,103,107,114, 10–12,26,31,35,41,43,51,56,65,68–70,73,74,90,117, 1 home with self-testing⁵, 13 mobile 10,11,13,26,41,43,51,56,64,68–70,73,74,90,117, 1 home with self-testing, 13 mobile 10,11,13,26,41,43,51,56,64,68–70,73,74,90,117, 2 index partner⁴⁸,⁶⁸, 2 campaign⁴⁷,⁷⁷, 20 facility VCT 5,12,13,26,41,43,51,56,64,68–70,73,74,90,117, and 6 facility PITC⁴⁸,⁶⁸,⁸⁶,⁹⁰,¹⁰³,¹⁰⁷, Results varied considerably by study (Supplementary Figures S29–S35). Community HTC generally tested a higher proportion of young adults than facility modalities; home with self-testing had the largest percentage (66%, 95% CI = 65–67%), followed by mobile, and then home (Fig. 2). Campaign reported 31% of young adults, but varied from 20–50% depending on the study (Supplementary Figure S32). Facility VCT had 46% (95% CI = 39–53%) and PITC had 38% (95% CI = 39–53%).

HIV positivity and CD4 count ≤350 cells ml⁻¹

Yield of HIV-positive people (HIV positivity) was reported in 29 home studies 14,15,18,29–31,35,37,38,45,63,64,68–70,73,74,90,117, 1 home with self-testing⁵, 13 mobile 10,11,13,26,41,43,51,56,64,68–70,73,74,90,117, 2 index partner⁴⁸,⁶⁸, 2 campaign⁴⁷,⁷⁷, 20 facility VCT 5,12,13,26,41,43,51,56,64,68–70,73,74,90,117, and 6 facility PITC⁴⁸,⁶⁸,⁸⁶,⁹⁰,¹⁰³,¹⁰⁷, Community-based strategies identified HIV-positive individuals at higher CD4 counts than facility HTC, with campaign having the lowest proportion with a CD4 count of 350 cells ml⁻¹ or less (26%, 95% CI = 22–30%) (Fig. 3). Home (39%, 95% CI = 32–46%) and mobile (38%, 95% CI = 36–41%) had similar proportions of HIV-positive individuals with a CD4 count of 350 cells ml⁻¹ or less, whereas facility VCT (66%, 95% CI = 60–72%) and PITC (71%, 95% CI = 67–75%) had the highest proportion.

Linkage and retention in care for HIV-positive people

Linkage to care was defined as visiting a clinic for community HTC and returning to the clinic to obtain CD4 count results (or enrolling in pre-ART care) for facility HTC. Linkage was reported for ten home ¹⁰,¹¹,¹³,¹⁴,¹⁵,¹⁶,¹⁹,²⁴,³⁴,³⁶,³⁷,³⁸,⁴¹,⁴³,⁶⁵,⁷¹,⁷²,⁷³,²⁵,²⁶, three mobile ²⁹,³⁴,³⁶, and five facility PITC ²⁸,³⁶,³⁸,³⁹,⁴⁵, Linkage achieved lower proportions of HIV-positive individuals visiting a clinic (26%, 95% CI = 18–36%) (Fig. 4). Mobile HTC achieved linkage rates of 37% (95% CI = 24–51%); rates were highest in two interventions conducted in South Africa, one of which used incentivized monetary recruitment and another which used a call centre to encourage linkage after HTC.⁴³,⁴⁵, Linkage to care from facility VCT was 61% (95% CI = 48–72%) and from PITC was 55% (95% CI = 39–71%) (Fig. 4). Time from HTC to linkage to care ascertainment varied by study (ranging from 1 to 12 months); the method of ascertainment (participant self-report or clinic record) also varied.

Four home HTC studies reported ART initiation among those eligible ¹⁴,¹⁶,⁴¹,⁴³. Similar to linkage to care, ART initiation was higher in home interventions with facilitated linkage (76%, 95% CI = 68–82%) compared with those without facilitated linkage (16%, 95% CI = 12–20%) (Fig. 5). ART initiation rates after home HTC with facilitated linkage were similar to those achieved through facility HTC. Initiation among those eligible was 64% (95% CI = 54–72%) in facility VCT and 70% (95% CI = 61–78%) in facility PITC, with 3 studies reporting initiation rates for VCT ³⁶,³⁸,³⁹ and 4 for facility PITC ³⁶,³⁸,³⁹,⁷³,⁷⁷. Self-testing showed an ART initiation rate of 29% (95% CI = 17–45%), although this number is among all HIV-positive individuals and is not restricted to those who are ART eligible because point of care CD4 testing was not conducted (Supplementary Figure S55).
Figure 4 | Linkage to care after community and facility HIV testing and counselling (HTC). Bars indicate 95% confidence intervals of random effects meta-analyses. N, sample size. PITC, provider-initiated testing and counselling; VCT, voluntary counselling and testing.

One study reported retention in care at 12 months after ART initiation for home HTC and two studies of both facility VCT and PITC reported retention — one at 6 months and one at 12 months. Not surprisingly, linkage rates were higher in the 6-month compared with the 12-month retention study (Supplementary Figure S59). Retention was highest for home HTC, although the sample size was small (93%, 95% CI = 83–97%) (Fig. 5). Facility VCT achieved 53% (95% CI = 32–71%) retention, and PITC retention achieved 64% (95% CI = 32–90%).

Cost per person tested
The average cost per person tested (2012 US dollars) for community HTC was $27.38 for mobile, $16.60 for index, $11.17 for campaign and $8.58 for home HTC (Supplementary Table S2 and Figure S61). The cost per person tested was highest for stand-alone VCT ($36.78) compared with two-thirds or more for facility HTC. The multidisease focus of campaigns may reduce stigma of HIV testing interventions. Our results suggest that campaign HTC can be a successful strategy for countries seeking to increase overall testing coverage in a short time frame.

Home HTC with self-testing had slightly lower coverage than other age groups. Home HTC with self-testing reached the greatest proportion of young adults (age 15 to 24 years) represent 39% of new infections in those over 15 years old, but have lower access to HTC and HIV care and poorer clinical outcomes than other age groups. Young adults (age 15 to 24 years) represent 39% of new infections in those over 15 years old, but have lower access to HTC and HIV care and poorer clinical outcomes than other age groups. Young adults (age 15 to 24 years) represent 39% of new infections in those over 15 years old, but have lower access to HTC and HIV care and poorer clinical outcomes than other age groups.

DISCUSSION
Across modalities, community HTC successfully reached target groups (men, young adults and first-time testers) with higher coverage than facility HTC (Table 1). High uptake of community HTC reflects acceptability of testing outside of health-care facilities. Community HTC identified HIV-positive individuals with higher CD4 counts who were likely to be earlier in their disease course. Combined with the potential of community HTC with facilitated linkage to achieve high linkage to treatment with similar retention rates as facility HTC, this suggests that scaling up community interventions could reduce the morbidity, mortality and transmission associated with late or non-initiation of ART. Although community interventions test a large number of HIV-negative individuals, HTC can reduce risky sexual behaviour and provide a means to link uninfected persons to primary prevention. This is particularly crucial for young women, who have high HIV incidence and can benefit from PrEP. Preventing HIV infections averts future treatment costs as well as morbidity. A recent modelling study found that ART scale up should be combined with primary prevention such as PrEP to achieve maximum HIV reduction. High coverage of HTC can also reduce stigma around testing.

Each HTC modality reaches distinct subpopulations and a combination of strategies will probably be necessary to achieve high ART coverage. Mobile and campaign HTC had high uptake (97%), as individuals who present at a mobile van or during a campaign are probably seeking out testing, but home HTC also achieved high uptake among people who were offered testing (82%). Home HTC also attained high population coverage, probably because offering testing door-to-door removes substantial barriers, including eliminating the need to actively seek out HIV testing. However, home HTC is less likely to reach men and young adults. A recent home HTC intervention in Botswana reached 85% of women in the target population compared with just 50% of men. This may be because women are more likely to be home at times when the intervention is conducted.

Campaign HTC has the potential to attain high coverage in large catchment areas and identify HIV-positive individuals at high CD4 counts (one-third of newly diagnosed HIV-positive individuals had a CD4 count of 350 cells µl⁻¹ or less compared with two-thirds or more for facility HTC). The multidisease focus of campaigns may reduce stigma of HIV testing interventions. Our results suggest that campaign HTC can be a successful strategy for countries seeking to increase overall testing coverage in a short time frame.

Home HTC with self-testing reached the greatest proportion of young adults of all modalities examined and is a promising strategy with high uptake. Young adults (age 15 to 24 years) represent 39% of new infections in those over 15 years old, but have lower access to HTC and HIV care and poorer clinical outcomes than other age groups. Young adults (age 15 to 24 years) represent 39% of new infections in those over 15 years old, but have lower access to HTC and HIV care and poorer clinical outcomes than other age groups. Young adults (age 15 to 24 years) represent 39% of new infections in those over 15 years old, but have lower access to HTC and HIV care and poorer clinical outcomes than other age groups. Young adults (age 15 to 24 years) represent 39% of new infections in those over 15 years old, but have lower access to HTC and HIV care and poorer clinical outcomes than other age groups. Young adults (age 15 to 24 years) represent 39% of new infections in those over 15 years old, but have lower access to HTC and HIV care and poorer clinical outcomes than other age groups.

Mobile HTC is the most effective strategy for reaching men — a target group in sub-Saharan Africa. Men are more likely to be lost at each step of the HIV treatment cascade; they are less likely to undergo testing, more likely to start ART at an advanced disease stage and more likely to interrupt treatment — all of which leads to increased morbidity and mortality. Qualitative studies highlight men's preference to test outside of facilities, so scale up of community interventions can meet this need. Future studies could investigate HTC at predominantly male workplaces, nightclubs or bars.

Index testing of sexual partners through active contact tracing is an efficient high-yield method that should be scaled up. HIV positivity was 55% in this group and the intervention attained a high coverage (41%). The HIV prevalence we
Data were also limited for key populations. Despite having an HIV prevalence up to eight times higher than the general population, interventions for key populations are community based (particularly mobile) as many high-risk groups are marginalized and do not have access to conventional health systems. Community-based HTC for MSM and PWIDs have been shown to have higher acceptance and greater HIV yield than clinic referral for HTC. In addition, self-testing is a potential strategy to reach key populations, as it demonstrates high acceptability and is considered convenient and private.

Costs of community-based and facility-based HTC vary by modality, country, scale of intervention, linkage strategy and costs included. Generally, community-based HTC and integrated facility HTC costs were comparable. However, stand-alone HTC had the highest cost per person tested, indicating that integrated HTC may be more cost-efficient than stand-alone services.

The limitations of our analysis included the heterogeneity across studies, which may not be accurately reflected in the pooled estimates. Differences in study design, geographical location (country, urban or rural area) and intervention year added to the heterogeneity. To address this, we used random effects meta-analysis and stratified on key variables (year <2005, country and facilitated linkage). In addition, large numbers of HIV-positive individuals were lost to follow-up in studies that reported linkage, so we considered these individuals unlinked in our analyses. If individuals linked at another clinic, our estimates may be conservative. Furthermore, assessment of linkage to care differed by study (self-report or clinic records review), as did time to linkage assessment, which varied from 1 to 12 months after HTC. In addition, CD4 count at diagnosis and ART uptake among those with eligible CD4 counts could only be assessed in community HTC interventions employing point-of-care CD4, as studies that report CD4 only for those visiting a clinic would not provide accurate denominators. Only studies reporting linkage to care among those eligible for ART were included in our main analysis. Also, estimates of coverage vary in their precision because some studies conducted population enumeration and others used census estimates of the catchment area. Finally, proportion of first-time testers, men and young adults tested are crude measures of relative uptake. For example, for home HTC, it is not possible to discern whether the 40% of those tested being
men reflects a lower coverage of men, or a greater coverage of women, or a combination of the two. Future studies reporting the number of men, first-time testers and young adults offered testing compared with those accepting testing would increase the accuracy of these measures. Our findings on uptake, HIV positivity and CD4 count at diagnosis are similar to a previously published meta-analysis.8

This analysis characterizes linkage and populations reached by HTC modalities to inform policymakers who are charged with addressing gaps in testing. Facility HTC, although important, is unlikely to be sufficient to curb the HIV epidemic because many people in sub-Saharan Africa do not have regular access to health care. Scaling a combination of community HTC, mobile testing to reach men, self-testing to reach young adults and outreach to high-risk populations, as appropriate to the local epidemic setting, is crucial to achieve high levels of serostatus and linkage to HIV treatment and prevention in sub-Saharan Africa.

1. Iwuji, C. C. et al. Evaluation of the impact of immediate versus WHO recommendations-guided antiretroviral therapy initiation on HIV incidence: the ANRS 1229 TaT (Treatment as Prevention) trial in Hlabisa sub-district, KwaZulu-Natal, South Africa: study protocol for a cluster randomised controlled trial. Trials 14, 230 (2013).

2. Kranzer, K., Govindasamy, D., Ford, N., Johnston, V. & Lawn, S. D. Quantifying and addressing losses along the continuum of care for people living with HIV infection in sub-Saharan Africa: a systematic review. J. Int. AIDS Soc. 15, 17383 (2012).

3. UNICEF. Uganda Fast Facts http://www.unicef.org/uganda/UNICEF_UGANDA_FAST_FACTS_July_2012.pdf (UNICEF, 2012).

4. UNAIDS. Fast-Tracking the AIDS Epidemic by 2030 http://www.unaids.org/sites/default/files/media_asset/UNAIDS_Fast_Track.pdf (UNAIDS, 2014).

5. Fylkesnes, K., Sandøy, I. F., Jurgensten, M., Chipojo, P., Mwangaala, S. & Michelo, S. Ch. Strong effects of home-based voluntary HIV counselling and testing on acceptance and equity: a cluster randomised trial in Zambia. Social Sci. Med. 86, 9–16 (2013).

6. Mushabe, M. et al. A systematic review of qualitative findings on factors enabling and deterring uptake of HIV testing in sub-Saharan Africa. BMC Public Health 13, 220 (2013).

7. Siedner, M. J., Ng, C. K., Bassett, I. V., Katz, I. T., Bangsberg, D. R. & Tsai, A. C. Trends in HIV positivity among Men Young adult (age <25 years) offere

Table 1 | Summary of HIV testing and counselling coverage and tester demographics.

| Parameter | Home | Mobile | Self-testing (home) | Campaign | Index | Key populations | Facility VCT | Facility PITC |
|-----------|------|-------|-------------------|----------|-------|----------------|------------|-------------|
| % 95% CI | % 95% CI | % 95% CI | % 95% CI | % 95% CI | % 95% CI | % 95% CI | % 95% CI | % 95% CI |
| Coverage (accepted/ target population) | 70 | 58–79 | 37 | 33–42 | 76 | 49–95 | 41 | 26–57 | 15 | 9–21 | 18 | 8–31 |
| Uptake (accepted offered) | 82 | 76–87 | 91 | 89–99 | 69 | 59–78 | 97 | 93–99 | 50 | 31–71 | 26 | 15–39 | 73 | 55–87 |
| Young adult (age <25 or 30) | 49 | 43–54 | 51 | 44–58 | 66 | 65–67 | 31 | 12–54 | 46 | 39–53 | 38 | 24–54 |
| Men | 40 | 39–42 | 50 | 47–54 | 44 | 42–48 | 41 | 37–46 | 41 | 38–44 | 42 | 39–46 |
| First-time testers | 58 | 48–67 | 63 | 50–74 | 55 | 28–81 | 55 | 83 | 71–91 | 53 | 40–66 | 55 | 48–62 |
| CD4 ≤350 cells μl-1 | 39 | 32–46 | 38 | 36–41 | 26 | 22–30 | 26 | 66 | 60–72 | 71 | 67–75 |
| HIV positivity | 10 | 8–12 | 11 | 8–13 | 8 | 5–11 | 6 | 4–10 | 55 | 49–61 | 16 | 9–26 | 18 | 13–23 | 20 | 17–24 |

CI, confidence interval; PITC, provider-initiated testing counselling; VCT, voluntary counselling and testing

578 | 3580 | 3 December 2015

SB3
41. Twumavorsie, H. et al. Household-based HIV counselling and testing as a platform for referral to HIV care and medical male circumcision in Uganda: a pilot evaluation. PloS ONE 7, e51620 (2012).

42. Twumewigye, Y., Wana, G., Kasasa, S., Mugasani, E. & Nwauha, F. High uptake of home-based, district-wide, HIV counselling and testing in Uganda. AIDS Patient Care STDS 24, 735–741 (2010).

43. van Rooyen, H. et al. High HIV testing uptake and linkage to care in a novel program of home-based HIV counselling and testing with facilitated referral in KwaZulu-Natal, South Africa. J. Acquir. Immune Defic. Syndr. 64, e1–e8 (2013).

44. Wachira, J., Ndege, S., Koech, J., Vreeman, R. C., Auyoo, P. & Braietstein, P. HIV testing uptake and prevalence among adolescents and adults in a large home-based HIV testing program in Western Kenya. J. Acquir. Immune Defic. Syndr. 65, e58–e66 (2014).

45. Welz, T. et al. Continued very high prevalence of HIV infection in rural KwaZulu-Natal, South Africa: a population-based longitudinal study. AIDS 21, 1467–1472 (2007).

46. Chang, A. et al. Uptake of community-based HIV testing during a multi-duty disease health campaign in rural Uganda. PloS ONE 9, e84317 (2014).

47. Luguda, E. et al. Rapid implementation of an integrated large-scale HIV counselling and testing, malaria, and diarrhea prevention campaign in rural Kenya. PloS ONE 5, e12435 (2010).

48. Luguda, E. et al. Comparison of home and clinic-based HIV testing among household members of persons taking antiretroviral therapy in Uganda: results from a randomized trial. J. Acquir. Immune Defic. Syndr. 55, 245–252 (2010).

49. Brown, L. B. et al. HIV partner notification is effective and feasible in sub-Saharan African: opportunities for HIV treatment and prevention. J. Acquir. Immune Defic. Syndr. 56, 437–442 (2011).

50. Armbruster, B., Helleringer, S., Kaiilihan-Phili, H., Mukandawire, J. & Kohler, H. P. Exploring the relative costs of contact tracing for increasing HIV care finding in sub-Saharan countries. J. Acquir. Immune Defic. Syndr. 58, e29–e36 (2011).

51. Bawumi, P. B. et al. Uptake of home-based HIV counseling and testing among clients who received home-based counseling and testing in Ghana. AIDS Care 27, 157–165 (2015).

52. Casale, L. J. et al. Low rates of repeat HIV testing despite increased availability of antiretroviral therapy in a rural community. BMC Health Care 8, 263 (2008).

53. Cawley, C. et al. Comparison of home- and clinic-based HIV counselling and testing: a randomized trial. AIDS Care 24, 132–137 (2012).

54. Fylkesnes, K. & Szücs, S. A randomized trial on acceptability of voluntary home-based HIV counseling and testing. Trop. Med. Int. Health 9, 566–572 (2004).

55. Isingo, R. et al. Trends in the uptake of voluntary counselling and testing for HIV in rural Tanzania in the context of the scale up of antiretroviral therapy. Trop. Med. Int. Health 17, e15–e25 (2012).

56. MacPherson, P. et al. Suboptimal patterns of provider initiated HIV testing and counseling, antiretroviral therapy eligibility assessment and referral in primary health clinic attenders in Blantyre, Malawi. Trop. Med. Int. Health 17, 507–512 (2012).

57. Nduku, V. et al. Provider-initiated HIV testing and counselling: An uptake study in two public community health centers in South Africa and implications for scale-up. PloS ONE 6, e27293 (2011).

58. Petene, N. W. & Feleke, A. D. Missed opportunities for earlier HIV testing and diagnosis at the health facilities of Dessie town, North East Ethiopia. BMC Public Health 10, 362 (2010).

59. Kayiga, F. R. et al. Provider-initiated HIV testing and counselling in Rwanda: acceptability among clinic attenders, workers, reasons for testing and predictors of testing. PloS ONE 9, e95549 (2014).

60. Kharsany, A. B., Kim, Q.A. & Karim, S. U. Uptake of provider-initiated HIV testing and counselling among patients attending an urban sexually transmitted disease clinic in South Africa — missed opportunities for early diagnosis of HIV infection. AIDS Care 22, 533–537 (2010).

61. Topp, S. et al. Opt-out provider-initiated HIV testing and counselling in primary care in South Africa: a community-based mobile HIV testing program in western Kenya. AIDS Patient Care STDS 21, 981–986 (2007).

62. Menzies, N. et al. The costs and effectiveness of four HIV counselling and testing strategies in Uganda. AIDS 23, 395–401 (2009).

63. Mulongo, E. M., Abdulla, A. S., Guerra, R. B. & Baine, S. O. Facility and home based HIV counselling and testing: A comparative analysis of uptake of services by rural communities in southwestern Uganda. BMC Health Services Res. 11, 54 (2011).

64. Wachira, J., Kinaiyio, S., Ndege, S., Mamlin, J. & Braietstein, P. What is the impact of home-based HIV counselling and testing on the clinical status of newly enrolled adults in a large HIV care program in Western Kenya? Clin. Infect. Dis. 54, 175–181 (2012).

65. Kavuma, D. et al. Linkage to care after provider-initiated HIV testing and counselling (PTC) versus voluntary HIV counselling and testing (VCT) for patients with sexually transmitted infections in Cape Town, South Africa. BMC Health Serv. Res. 14, 350 (2014).

66. Moodley, J., Bryan, M., Tunyk, K. & Kedumn, S. M. A clinical audit of provider-initiated HIV counselling and testing in a gynaecological ward of a district hospital in KwaZulu-Natal, South Africa. S Afr. J. Obs. Gynae. 20, 8–11 (2014).

67. Wanyenze, R. K. et al. Acceptability of routine HIV testing and counselling, and HIV sero-prevalence in Uganda hospitals. Bull. World Health Organ. 86, 302–309 (2008).

68. Mbuyi, T. et al. Initial outcomes of an emergency department rapid HIV testing program in western Kenya. AIDS Patient Care STDS 21, 981–986 (2007).

69. Menzies, N. et al. The costs and effectiveness of four HIV counseling and testing strategies in Uganda. AIDS 23, 395–401 (2009).

70. Mulongo, E. M., Abdulla, A. S., Guerra, R. B. & Baine, S. O. Facility and home based HIV counselling and testing: A comparative analysis of uptake of services by rural communities in southwestern Uganda. BMC Health Services Res. 11, 54 (2011).

71. Wachira, J., Kinaiyio, S., Ndege, S., Mamlin, J. & Braietstein, P. What is the impact of home-based HIV counselling and testing on the clinical status of newly enrolled adults in a large HIV care program in Western Kenya? Clin. Infect. Dis. 54, 175–181 (2012).

72. van Rie, A. et al. Increasing access to HIV counseling and testing through mobile services in Kenya: strategies, utilization, and cost-effectiveness. J. Acquir. Immune Defic. Syndr. 64, S405–414 (2014).

73. Kranzer, K. et al. Incentivized recruitment of a population sample to a mobile HIV testing service increases the yield of newly diagnosed cases, including those in need of antiretroviral therapy. HIV Med. 13, 132–137 (2012).

74. Lino, T. et al. Four models of HIV counselling and testing: utilization and test results in rural South Africa. PloS ONE 9, e102367 (2014).

75. Meehan, S. A., Naidoo, P., Claassen, M. M., Lombard, C. & Beyers, N. Characteristics of clients who access mobile compared to clinic HIV counselling and testing services: a matched study from Cape Town, South Africa. BMC Health Serv. Res. 14, 658 (2014).

76. Morin, S. et al. Removing barriers to knowing HIV status: same-day mobile HIV testing in Zimbabwe. J. Acquir. Immune Defic. Syndr. 41, 218–224 (2006).

77. Sweat, M. et al. Community-based intervention to increase HIV testing and case detection in people aged 16–25 years in Tanzania, Zimbabwe, and Thailand (NIMH Project Accept, HPTN 043): a randomised study. Lancet Infect. Dis. 11, 525–532 (2011).

78. Verbiest, V. et al. High uptake of home-based voluntary HIV counselling and testing and symptom assessment at a primary care clinic in South Africa. PloS ONE 9, e105428 (2014).

79. Kalibala, S., Tun, W., Cherutich, P., Nganga, A., Oweya, E. & Olouch, P. Factors associated with acceptability of HIV self-testing among health care workers in Kenya. AIDS Care 19, 888–895 (2015).

80. Pant Pai, N. et al. Will an unsupervised self-testing strategy for HIV work in health workers of South Africa? A cross sectional pilot feasibility study. PloS ONE 8, e79772 (2013).

81. Arensd, V. et al. Clinical screening for HIV in a health centre setting in urban Kenya: an entry point for voluntary counselling, HIV testing and early diagnosis of HIV infection? Trop. Doc. 37, 45–47 (2007).
