Annual home-based HIV testing in the Chókwè Health Demographic Surveillance System, Mozambique, 2014 to 2019: serial population-based survey evaluation

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Abstract

Introduction: WHO recommends implementing a mix of community and facility testing strategies to diagnose 95% of persons living with HIV (PLHIV). In Mozambique, a country with an estimated 506,000 undiagnosed PLHIV, use of home-based HIV testing services (HBHTS) to help achieve the 95% target has not been evaluated.

Methods: HBHTS was provided at 20,000 households in the Chókwè Health Demographic Surveillance System (CHDSS), Mozambique, in annual rounds (R) during 2014 to 2019. Trends in prevalence of HIV infection, prior HIV diagnosis among PLHIV (diagnostic coverage), and undiagnosed HIV infection were assessed with three population-based surveys conducted in R1 (04/2014 to 04/2015), R3 (03/2016 to 12/2016), and R5 (04/2018 to 03/2019) of residents aged 15 to 59 years. Counts of patients aged ≥15 years tested for HIV in CHDSS healthcare facilities were obtained from routine reports.

Results: During 2014 to 2019, counsellors conducted 92,512 home-based HIV tests and newly diagnosed 3711 residents aged 15 to 59 years. Prevalence of HIV infection was stable (R1, 25.1%; R3 23.6%; R5 22.9%; p-value, 0.19). After the first two rounds (44,825 home-based tests; 31,717 facility-based tests), diagnostic coverage increased from 73.8% (95% CI 70.3 to 77.2) in R1 to 93.0% (95% CI 91.3 to 94.7) in R3, and prevalence of undiagnosed HIV infection decreased from 6.6% (95% CI 5.6 to 7.5) in R1 to 1.7% (95% CI 1.2 to 2.1) in R3. After two more rounds (32,226 home-based tests; 46,003 facility-based tests), diagnostic coverage was 95.4% (95% CI 93.7 to 97.1) and prevalence of undiagnosed HIV infection was 1.1% (95% CI 0.7 to 1.5) in R5. Prevalence of having last tested at home was 12.7% (95% CI 11.3 to 14.0) in R1, 45.2% (95% CI 43.4 to 47.0) in R3, and 41.4% (95% CI 39.5 to 43.2) in R5, and prevalence of having last tested at a healthcare facility was 45.3% (95% CI 43.3 to 47.3) in R1, 40.1% (95% CI 38.4 to 41.8) in R3, and 45.2% (95% CI 43.3 to 47.0) in R5.

Conclusions: HBHTS successfully augmented facility-based testing to achieve HIV diagnostic coverage in a high-burden community of Mozambique. HBHTS should be considered in sub-Saharan Africa communities striving to diagnose 95% of persons living with HIV.

Keywords: home-based HIV testing and counselling; HIV diagnostic coverage; prevalence of undiagnosed HIV infection; Mozambique

Additional information may be found under the Supporting Information tab for this article.

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1 | INTRODUCTION

To achieve HIV epidemic control, countries are striving to diagnose 95% of persons living with HIV (PLHIV), initiate and retain on antiretroviral therapy (ART) 95% of those diagnosed, and ensure 95% of those on ART are virally suppressed (95-95-95) [1]. Of the 95-95-95 targets, diagnosing 95% of PLHIV has for many countries been the most challenging to reach [2-4]. In Mozambique, an estimated 77% of 2.2 million PLHIV of all ages had received an HIV diagnosis by the end of 2019, including 86% of women and 66% of men aged ≥15 years [4]. In 2020, estimated diagnostic coverage in Mozambique was <90% in nine of 11 provinces, and was particularly low among women and men aged 15 to 24 years nationally (women, 71%; men 45%) [5,6].
To achieve 95% diagnostic coverage, WHO recommends implementing a mix of testing strategies including HBHTS in high-burden communities [7]. Systematic reviews of over 30 studies suggest that HBHTS is cost-effective and superior to other strategies in testing a large majority of residents in geographical populations (testing coverage) and in diagnosing PLHIV sooner after acquiring HIV [8-11]. Few studies, however, have evaluated if HBHTS, in addition to standard testing in healthcare facilities, can achieve 95% diagnostic coverage; none have been conducted in Mozambique [12,13].

To assess the potential of HBHTS to augment facility-based testing to achieve 95% diagnostic coverage and reduce the prevalence of undiagnosed HIV infection in a high-burdened population, annual HBHTS was offered at all households in the Cho'kwè Health Demographic Surveillance System (CHDSS) during 2014 to 2019. Located in Gaza Province of southern Mozambique, CHDSS conducts annual demographic and vital-events surveillance of approximately 100,000 residents in Cho'kwè town and seven rural villages, representing approximately half of the population in Cho'kwè District.

In this paper, we report trends in the annual number of residents aged 15 to 59 years who were tested at home and received an HIV diagnosis for the first time (new diagnosis), diagnostic coverage among PLHIV, and population prevalence of undiagnosed HIV infection, by age group, sex, and HIV-risk characteristics. Evaluating the distribution and trends of undiagnosed HIV infection is important to identify PLHIV populations underserved by HBHTS and standard facility-based testing strategies. Our findings may be helpful to countries considering the targeted application of HBHTS to reduce disparities in undiagnosed HIV infection and to help diagnose 95% of PLHIV in high-burden communities.

2 | METHODS

2.1 | HBHTS intervention

After a partial rollout during 2013, comprehensive door-to-door HBHTS was conducted in five annual rounds (R1 to R5) from January 2014 through March 2019. During each round, lay counsellors certified to provide rapid HIV testing and counselling visited approximately 20,000 homes that compose the CHDSS and offered HBHTS to all encountered household members. Rapid HIV testing was conducted in accordance with national guidelines: the screening test was Determine, and the second test, Uni-Gold, was conducted if Determine was reactive [14]. Participants with reactive results for both tests were considered HIV positive [14]. National testing guidelines did not change during R1 to R5. All HBHTS clients were provided condoms, risk-reduction counselling, and referral for medical care if needed. HIV-positive clients were referred for immediate HIV care and re-visited up to five times over six months to provide supportive counselling for early ART initiation and retention.

2.2 | Facility-based testing

During R1 to R5, facility-based rapid HIV testing in CHDSS was implemented in accordance with national strategic plans supported by the United States President’s Emergency Plan for AIDS Relief [15]. HIV testing at healthcare facilities was conducted in accordance with national guidelines [14]. The number of HIV tests conducted of patients aged ≥15 years at all nine healthcare facilities located in CHDSS during R1 to R5 was obtained from routine Ministry of Health reports. New HIV diagnoses among CHDSS residents tested at healthcare facilities were not measured and are not reportable.

2.3 | HBHTS evaluation

We conducted three population-based, cross-sectional surveys in rounds 1, 3, and 5 to evaluate trends in the prevalence of HIV risk and testing behaviour, prior HIV diagnosis among PLHIV, and undiagnosed HIV infection among CHDSS residents. For each survey round, a separate random sample of households was drawn from the most recent census of CHDSS households in Cho'kwè town (urban) and seven rural villages (Appendix S1). All households in the updated census were eligible for random selection, including those selected for surveys in prior rounds. The number of households selected for each survey was expected to yield a target sample of 4760 participants that would provide >90% power to detect expected increases in diagnostic coverage among HIV-positive residents, by urban or rural residence. Because of lower than expected participation rates, attributed in part to some household members working in South Africa, the number of randomly selected households was increased from 2805 in R1 to 4613 and 4577 in R3 and R5, respectively [16]. All contacted members aged 15 to 59 years of selected households were invited to participate in an interview. Interviews were conducted in Shangaan or Portuguese and included standard measures on demographics, HIV risk behaviours, and location and results of their last HIV test. After the interview, consenting participants were tested for HIV in accordance with national guidelines [14]. For participants who tested HIV positive, 1 mL of whole blood was collected and processed into dried blood spots (DBS). Viral load testing was performed on DBS with the Roche COBAS® AmpliPrep/COBAS® TaqMan® HIV-1 Test at the US Centers for Disease Control and Prevention (CDC) (R1 to R3) and the Instituto Nacional de Saúde, Marracuene, Mozambique (R4 to R5) [17,18].

2.4 | Outcome definitions

Prior HIV diagnosis among HIV-positive survey participants was defined as either (1) reporting having tested HIV positive previously, (2) having tested HIV positive at home in a prior round, or (3) testing HIV positive and having a suppressed viral load (HIV-1 RNA concentration <1000 copies/μL). Undiagnosed HIV infection (new HIV diagnosis) among HIV-positive participants was defined as not having received a prior diagnosis.

2.5 | Statistical analysis

For each round, we report the number of home-based tests conducted and the percentage of new HIV diagnoses, by sex, age group, and urban or rural residence. In the two rounds before R3 and R5 surveys, we also report the number of tests conducted and new diagnoses (HBHTS only) at CHDSS homes and healthcare facilities. For each of the three cross-sectional
3 | RESULTS

3.1 | HBHTS intervention

During R1 to R5, counsellors conducted 92,512 home-based HIV tests, including 30,072 (32.5%) among men and 43,214 (46.7%) among residents aged 15 to 24 years. Total (monthly) tests declined from 24,979 (1921) in R1 to 15,461 (1288) in R5 (Table S1, Figure 1). Trends in tests per round were similar by sex and age group (Figure 1). From R1 to R5, the median age among residents tested at home decreased from 31 (interquartile range (IQR) 21 to 41) to 25 (IQR 19 to 38) years among women, and from 25 (IQR 18 to 38) to 20 (IQR 17 to 28) years among men. Of 68,620 persons aged 15 to 59 years who ever resided in CHDSS, 46,090 (67.2%) had tested at home at least once (Figure 2).

During R1 to R5, 3711 residents tested at home received a new HIV diagnosis, including 980 men and 964 persons aged 15 to 24 years. The percentage of new diagnoses of tests conducted declined from 7.5% (R1) to 1.3% (R5) overall, with similar trends for women and men (Figure 3). Among residents aged 15 to 24 years, the percentage of new diagnoses in each round was three to seven times higher among women (6.1% to 1.4%) than men (1.6% to 0.2%). Among residents aged ≥25 years, the proportion of new diagnoses in each round was similar among women and men (Figure 3).

During R1 to R2, 59.1% (32,682/55,282) of all residents had tested at home at least once, 48% (44,825/92,512) of all home-based tests had been conducted, and 74% (2755/3711) of all residents newly diagnosed at home had been identified and referred to HIV care. During R3 to R4, 32,226 home-based tests had been conducted and an additional 20% (755/3711) of all residents newly diagnosed at home had been identified and referred to HIV care (Table S1).

3.2 | Facility-based testing

During R1 to R5, of 113,527 HIV tests among patients aged ≥15 years at CHDSS healthcare facilities, 31,717 (28%) were conducted during R1 to R2 and 46,003 (41%) were conducted during R3 to R4 (Table S2).

3.3 | HBHTS evaluation

Of residents aged 15 to 59 years in sampled households, 2988, 5048, and 4065 were interviewed and contributed complete analysis records in R1, R3, and R5, respectively (Figure 4). In R3 and R5, men aged 15 to 59 years represented 37% and 38% of members of sampled households, and 27% and 29% of analysed records, respectively. From R1 to R5, prevalence of having ≥1 sexual partners, sometimes or never using condoms, and weekly or daily alcohol use decreased, and prevalence of having tested for HIV in the past year increased (Table 1). Prevalence of having last tested for HIV at a healthcare facility was stable across rounds (45.3% to 45.2%), whereas the prevalence of having last tested at home increased from 12.7% in R1, to 45.2% and 41.4% in R3 and R5, respectively (Table 1).

The prevalence of HIV infection (25.1% to 22.9%) was stable across rounds, and consistently higher among women than men, and residents aged 35 to 44 years than all other age groups (Tables 1 and 2). Among residents aged 15 to 24 years, HIV prevalence across survey rounds was at least three-fold higher among women (11.9% to 8.3%) than men (2.7% to 2.2%) (Table 2). The prevalence of prior HIV diagnosis among PLHIV increased from 73.8% in R1, to 93.0% and 95.4% in R3 and R5, respectively. In R5, prevalence of prior HIV diagnosis was >90% in all subgroups except those aged 15 to 24 years (88.5%) (Table 2).

Compared with R1, the prevalence of undiagnosed HIV infection in R3 declined 75% overall (Prevalence Ratio (PR) 0.25; 95% CI 0.19 to 0.34), and by at least 66% (PR ≤ 0.34) among all sex, age, residence, and risk-behaviour subgroups (Table 3). Compared with R3, prevalence of undiagnosed infection in R5 was not statistically significantly lower overall and for all subgroups except residents in rural villages and those who reported not testing in the past five years (Table 3).

In R1 and R3, compared with comparison groups, the prevalence of undiagnosed HIV infection was higher among residents aged 25 to 44 years, and among residents who had sexual partners (R3 only), sometimes or never used condoms, used alcohol at least weekly, and who had never previously tested or last tested ≥5 years ago. In R5, prevalence of undiagnosed HIV infection was similar among all demographic and risk-behaviour subgroups (Table 3).

4 | DISCUSSION

In a high-burden district of Mozambique during 2014 to 2019, annual rounds of HBHTS in 20,000 households newly diagnosed 3711 PLHIV, including nearly 1000 each of men and young adults aged 15 to 24 years, two groups with consistently low diagnostic coverage [1-5]. After the first two rounds (44,825 home-based tests; 31,717 facility-based tests), 59% of residents aged 15 to 59 years had tested at home at least once, the prevalence of undiagnosed HIV infection decreased 75%, and diagnostic coverage among PLHIV increased from 73.8% to 93.0%, exceeding in 2016 the 90%
target for 2020 [19]. After another two rounds (32,226 home-based tests; 46,003 facility-based tests), demographic and risk-behaviour disparities in undiagnosed HIV infection were eliminated and diagnostic coverage in CHDSS reached 95% overall, achieving in 2019 the target for 2030 [1]. Findings from CHDSS are consistent with more than 30 studies in sub-Saharan Africa on high uptake and testing coverage of HBHTS, and with two recent test and treat trials that used two or more rounds of door-to-door HBHTS, in addition to standard facility-based testing, to diagnose >90% of PLHIV in communities in Zambia and South Africa [8-10,12,13]. Comparative effects of HBHTS on diagnostic coverage among PLHIV in Mozambique have not been reported. However, modelled estimates suggest that in Gaza province from 2014 to 2016, diagnostic coverage among residents aged ≥15 years increased an absolute 9% (76% to 85%) among women and 11% (59% to 71%) among men [5,6]. In contrast, after two rounds of HBHTS in CHDSS (located in Gaza), estimated diagnostic coverage during this period increased an absolute 16% (78% to 94%) among women and 28% (63% to 91%) among men aged 15 to 59 years. During 2014 to 2019, HIV testing strategies in Mozambique were largely restricted to healthcare facilities and for partners and children of PLHIV [15]. Notably, in CHDSS, the prevalence of having last tested for HIV in a healthcare facility did not change (45% in 2014, 40% in 2015 to 01/2016; R3 = 03/2016 to 12/2016; R4 = 03/2017 to 11/2017; R5 = 04/2018 to 03/2019).

Figure 1. Home-based HIV tests conducted among women and men, by age group, median age of residents tested, and round (R). Chökwe Health Demographic Surveillance System, Chökwe Mozambique, 2014 to 2019. R1 = 04/2014 to 04/2015; R2 = 05/2015 to 01/2016; R3 = 03/2016 to 12/2016; R4 = 03/2017 to 11/2017; R5 = 04/2018 to 03/2019.
negative residents should re-test annually [20]. Notably, even though the proportion of home tests among young adults increased in every round, after four rounds of HBHTS and standard facility-based testing, diagnostic coverage among PLHIV aged 15 to 24 years reached only 88%. Additionally, after two rounds of HBHTS, prevalence of undiagnosed infection remained higher in several subgroups including residents with sexual- and alcohol-related risks, and those who had not tested in five or more years. These findings are consistent with recent studies suggesting that to diagnose ≥95% of young adults and eliminate disparities in undiagnosed infection within 1 to 2 rounds of HBHTS, additional community-based testing strategies are needed such as mobile testing at bars and clubs and use of self-test kits [7,9,10,20-22].

During 2014 to 2019 when HIV prevalence in CHDSS was stable at approximately 24%, HBHTS yield of new diagnoses was slightly higher than the prevalence of undiagnosed infection in the first (7.5% vs. 6.6%), third (2.9% vs. 1.7%), and fifth (1.3% vs. 1.1%) rounds. Additionally, HBHTS yield of new diagnoses among residents aged 15 to 24 years in all rounds was at least three-fold higher among women than men, reflecting underlying HIV gender disparities among young adults in CHDSS and throughout sub-Saharan Africa [2-4]. These findings suggest that home-based testing in CHDSS was an effective population-based testing strategy as the yield of new HIV diagnoses approximated the underlying prevalence and distribution of undiagnosed infection, even as the prevalence of undiagnosed infection decreased. Although the prevalence of undiagnosed infection in CHDSS decreased 36% (PR 0.64; 95% CI 0.41 to 1.01) between the third and fifth rounds, the reduction was not statistically significant, attributed in part to the diminishing returns of HBHTS. While index and facility-based testing typically have a higher yield than HBHTS, these strategies alone are insufficient to achieve population-level testing and diagnostic coverage [7-10,22]. Notably, of the four recent trials that have been able to achieve ≥90% diagnostic coverage among PLHIV in sub-Saharan Africa, all implemented some form of HBHTS [20].

HBHTS achieves high testing coverage in populations by reducing well-known barriers to testing including costs in transportation, time, and lost work, fear of stigma and discrimination, and unfamiliarity with or negative perceptions about healthcare [7-10,20,23]. Other social and medical benefits of HBHTS include testing of couples and undiagnosed children,
normalizing HIV testing and treatment in communities, and diagnosing PLHIV sooner after infection [7-10,20]. Nonetheless, despite repeated findings of these benefits and success in achieving high testing and diagnostic coverage, HBHTS is now rarely supported programmatically in sub-Saharan Africa, primarily due to costs [24].

Early studies suggested costs per person tested were lower for HBHTS (USD $2 to $14) than facility-based testing (USD $12 to $94) [8-11]. More recent studies suggest that costs per person tested vary considerably but are generally higher for HBHTS ranging from $6 to $55 USD, than facility-based testing ranging from $5 to $31 USD [25,26]. These studies, however, did not consider averted costs. Because HBHTS is superior to facility-based testing in achieving diagnostic coverage and diagnosing PLHIV earlier, combined with effective linkage-to-ART services, HBHTS may be more cost-effective than facility-based testing in deaths and disability-adjusted life years averted [7-10].

The importance of providing effective linkage services is underscored by over 15 studies in sub-Saharan Africa, including one in Mozambique, suggesting that only 18%-51% of PLHIV diagnosed in community settings enrol early in HIV care when referral is the only linkage service [10,27-29]. The findings in this report are subject to at least five limitations. First, because the evaluation did not include control communities and CHDSS residents who were newly HIV diagnosed in healthcare facilities remains unknown, the effect of HBHTS on diagnostic coverage and prevalence of undiagnosed HIV infection could not be estimated. The effect, however, is expected to be large since in 2014 an estimated 3473 (52,618*0.066) HIV-positive residents aged 15 to 59 years were undiagnosed, and 2755 (79%) were tested and diagnosed at home in the first two rounds. Second, counts of home- and facility-based tests do not represent unique persons who might test more than once within and across rounds. Also, because patient residence was not recorded on facility test registers, reported facility-based HIV tests do not represent tests among residents of any geographical area including CHDSS or Chokwe District. Many residents outside CHDSS are known to receive care at Chokwe hospitals and likely contribute to HIV-test counts. Third, although all prevalence estimates were weighted to the census population, residual bias might reduce the validity of trends among men.

| Round 1 (04/2014 – 04/2015) | Round 2 (03/2016 – 12/2016) | Round 3 (04/2018 – 03/2019) |
|-----------------------------|-----------------------------|-----------------------------|
| 20,990 Households           | 19,913 Households           | 15,884 Households           |
| 2,805 Sampled               | 4,613 Sampled               | 6,577 Sampled               |
| 5,587 Age eligible (15-59)  | 8,805 Age eligible (15-59)  | 7,820 Age eligible (15-59)  |
| • 1,943 (35%) men           | • 1,781 (37%) men           | • 2,158 (38%) men           |
| • 2,218 (40%) ages 15-24   | • 3,880 (58%) ages 15-24   | • 3,197 (45%) ages 15-24   |
| 4,729 (83%) Contacted       | 6,058 (69%) Contacted       | 1,768 (31%) Not contacted   |
| • 1,472 (31%) men           | • 1,800 (30%) men           | • 1,476 men                 |
| • 1,813 (38%) ages 15-24   | • 2,282 (38%) ages 15-24   | • 1,098 ages 15-24          |
| 3,060 (55%) Surveyed        | 5,097 (58%) Surveyed        | 941 (16%) Declined          |
| • 1,124 (37%) men           | • 1,306 (27%) men           | • 415 men                   |
| • 1,219 (40%) ages 15-24   | • 1,046 (18%) ages 15-24   | • 336 ages 15-24            |
| 2,988 (53%) Analyzed        | 5,048 (57%) Analyzed        | 49 (1%) Missing data        |
| • 1,087 (36%) men           | • 1,306 (27%) men           | • 24 men                    |
| • 1,881 (40%) ages 15-24   | • 1,046 (18%) ages 15-24   | • 17 ages 15-24             |
| 72 (2%) Missing data        | 4,465 (13%) Analyzed        | 47 (1%) Missing data        |
| • 37 men                    | • 1,770 (29%) men           | • 5 men                     |
| • 38 ages 15-24             | • 1,835 (45%) ages 15-24   | • 13 ages 15-24             |

Figure 4. Participation in cross-sectional household surveys, Chokwe Health Demographic Surveillance System, Chokwe District, Mozambique, 2014 to 2019.
who were underrepresented in survey rounds 3 and 5. Because of cost considerations, research staff were not able to revisit homes repeatedly in these rounds, and most men did not participate because they were never contacted. Fourth, trends in the prevalence of undiagnosed infection might be biased downwards as proportionally fewer participants in R3 and R5 than R1 reported sexual- and alcohol-related risk behaviours. However, HIV prevalence was similar across rounds, suggesting that this potential bias is likely to be small. Although misclassification might also bias trends in undiagnosed infection, only 12 participants across survey rounds were reclassified as having received a prior HIV diagnosis based on viral load suppression results, suggesting that trends were not affected by misclassification. Finally, CHDSS prevalence of prior HIV diagnosis among PLHIV in 2014 (73.8%) is higher than modelled estimates for Gaza province in 2014 that adjusted for underreporting (69.4%) [5,6]. Although differences may be attributed to the uncertainty of modelled estimates or bias in our study, higher baseline diagnostic coverage in CHDSS might also be attributed, in part, to HBHTS that was provided at a lower scale in CHDSS before 2014.

### Table 1. Prevalence of HIV risk and testing behaviour among residents aged 15 to 59 years, Chââvo Health Demographic Surveillance System, Chââvo District, Mozambique, 2014 to 2019

|                      | Round 1 (04/2014 to 04/2015) | Round 3 (03/2016 to 12/2016) | Round 5 (04/2018 to 03/2019) | p-value\(^b\) |
|----------------------|-------------------------------|-------------------------------|-------------------------------|----------------|
| **Total**            | 2988 –                        | 5048 –                        | 4065 –                        | –              |
| **Sex**              |                               |                               |                               |                 |
| Women                | 1901 62.1 (60.2 to 63.9)       | 3682 62.1 (60.4 to 63.7)      | 2895 61.7 (60.0 to 63.4)      |                 |
| Men                  | 1087 37.9 (36.1 to 39.8)       | 1366 37.9 (36.3 to 39.6)      | 1170 38.3 (36.6 to 40.0)      |                 |
| **Age group (years)**|                               |                               |                               |                 |
| 15 to 24             | 1181 41.1 (39.2 to 42.9)       | 1927 41.5 (39.5 to 42.6)      | 1835 40.9 (39.2 to 42.6)      |                 |
| 25 to 44             | 1259 42.5 (40.5 to 44.5)       | 2091 42.5 (40.8 to 44.2)      | 1500 42.6 (40.7 to 44.6)      |                 |
| 45 to 59             | 548 16.4 (15.1 to 17.7)        | 1030 16.5 (15.3 to 17.6)      | 730 16.5 (15.2 to 17.8)       |                 |
| **Residence**        |                               |                               |                               |                 |
| Chââvo town          | 1387 63.1 (60.6 to 65.5)       | 1840 62.8 (60.7 to 64.8)      | 1587 62.9 (60.7 to 65.2)      |                 |
| District villages    | 1601 36.9 (34.9 to 39.4)       | 3208 37.2 (35.2 to 39.3)      | 2478 37.1 (34.8 to 39.3)      |                 |
| **Sexual partners in past 12 months** |                           |                               |                               | <0.0001         |
| 0                    | 461 15.1 (13.7 to 16.5)        | 1040 19.4 (18.1 to 20.7)      | 1028 23.1 (21.6 to 24.5)      |                 |
| 1                    | 1751 58.0 (56.2 to 59.9)       | 3195 59.8 (58.1 to 61.5)      | 2806 69.7 (68.1 to 71.4)      |                 |
| >1                   | 773 26.9 (25.1 to 28.7)        | 801 20.8 (19.2 to 22.3)       | 229 7.2 (6.1 to 8.3)          |                 |
| **Condom use in past 12 months** |                           |                               |                               | <0.0001         |
| No sexual partners/always | 616 21.5 (19.8 to 23.1)       | 1055 23.7 (21.2 to 25.2)      | 1073 27.0 (25.3 to 28.6)      |                 |
| Sometimes/never      | 2368 78.5 (76.9 to 80.2)       | 3925 76.3 (74.8 to 77.9)      | 2970 73.0 (71.4 to 74.7)      |                 |
| **Alcohol use in past 3 months** |                           |                               |                               | <0.0001         |
| Never/monthly        | 2575 85.7 (84.3 to 87.2)       | 4488 87.7 (86.4 to 88.9)      | 3788 91.7 (90.6 to 92.9)      |                 |
| Daily/weekly         | 398 14.3 (12.8 to 15.7)        | 517 12.3 (11.1 to 13.6)       | 262 8.3 (7.1 to 9.4)          |                 |
| **Prior HIV test**   |                               |                               |                               | <0.0001         |
| <1 year              | 1104 39.1 (37.1 to 41.0)       | 1972 42.5 (40.7 to 44.2)      | 2379 60.0 (58.0 to 61.9)      |                 |
| 1 to 4 years         | 911 30.7 (28.9 to 32.5)        | 2484 47.1 (45.3 to 48.9)      | 1174 28.8 (27.0 to 30.6)      |                 |
| ≥5 years/no prior HIV test | 896 30.3 (28.5 to 32.1)       | 535 10.4 (9.4 to 11.4)        | 470 11.2 (10.1 to 12.4)       |                 |
| **Location of last HIV test** |                           |                               |                               | <0.0001         |
| Never tested         | 697 22.6 (21.0 to 24.3)        | 333 7.3 (6.4 to 8.1)          | 241 5.6 (4.8 to 6.3)          |                 |
| District hospital/clinic | 1347 45.3 (43.3 to 47.3)      | 2023 40.1 (38.4 to 41.8)      | 1849 45.2 (43.3 to 47.0)      |                 |
| District home        | 386 12.7 (11.3 to 14.0)        | 2317 45.2 (43.4 to 47.0)      | 1604 41.4 (39.5 to 43.2)      |                 |
| Other location       | 535 19.4 (17.8 to 21.0)        | 336 7.5 (6.5 to 8.5)          | 350 7.9 (6.9 to 8.9)          |                 |
| **HIV positive**     |                               |                               |                               | 0.1901          |
| No                   | 2230 74.9 (73.1 to 76.7)       | 3717 76.4 (75.0 to 77.9)      | 3119 77.1 (75.4 to 78.7)      |                 |
| Yes                  | 758 25.1 (23.3 to 26.9)        | 1331 23.6 (22.1 to 25.0)      | 946 22.9 (21.3 to 24.6)       |                 |

CI, confidence interval.  
\(^a\)All estimates were weighted to the CHDSS census population by age group, sex, and urban (Chââvo town) or rural (district villages) residence, and adjusted for within-household correlation; \(^b\)Rao-Scott chi-square test of differences in prevalence estimates across survey rounds, not reported for variables used for census-based weights.
| Sex and Age Group | Participants | HIV prevalence | Prior HIV diagnosis |
|-------------------|-------------|---------------|--------------------|
| **Total**         | 2988        | 758 (25.1%)   | 73.8% (95% CI: 70.3% - 77.2%) |
| **Women**         | 1901        | 558 (28.8%)   | 78.2% (95% CI: 74.6% - 81.8%) |
| **Men**           | 1087        | 200 (19.1%)   | 62.8% (95% CI: 55.3% - 70.2%) |
| **Age group (years)** |            |              |                    |
| 15 to 24          | 1181        | 89 (7.8%)     | 51.6% (95% CI: 41.0% - 62.3%) |
| 25 to 34          | 741         | 253 (33.0%)   | 72.0% (95% CI: 66.0% - 78.0%) |
| 35 to 44          | 518         | 244 (46.2%)   | 79.4% (95% CI: 71.1% - 84.8%) |
| 45 to 59          | 948         | 172 (17.7%)   | 75.6% (95% CI: 71.3% - 79.7%) |
| **Residence**     |             |               |                    |
| Chókwé town       | 1387        | 343 (25.2%)   | 85.9% (95% CI: 81.3% - 89.5%) |
| District villages | 1601        | 415 (25.4%)   | 84.1% (95% CI: 79.6% - 88.6%) |

Cl. CI, confidence interval.

aOf HIV-positive participants. Prior HIV diagnosis = (1) reporting having tested HIV positive previously to standard interview questions, (2) having tested HIV positive at home in a prior round, or (3) having an HIV-1 RNA concentration <1000 copies/l. All estimates were weighted to the CHDSS census population by age group, sex, and urban (Chókwé town) or rural (CHDSS villages) residence, and adjusted for within-household correlation. Reported for sex and age groups with at least 50 HIV-positive participants.
Table 3. Prevalence of undiagnosed HIV infection among residents aged 15 to 59 years, and intra- and inter-survey prevalence ratios, Chokwè Health Demographic Surveillance System, Chokwè District, Mozambique, 2014 to 2019

|                          | Round 1 (04/2014 to 04/2015) | Round 3 (03/2016 to 12/2016) | Round 5 (04/2018 to 03/2019) | Round 3 vs. Round 1 | Round 5 vs. Round 3 |
|--------------------------|-------------------------------|-------------------------------|-------------------------------|---------------------|---------------------|
| n                        | 2983                          | 5048                          | 4065                          | 3924                | 2406                |
| % (95% CI)               | 6.6 (5.6 to 7.5)              | 1.7 (1.2 to 2.1)              | 1.1 (0.7 to 1.5)              | 0.25 (0.19 to 0.34) | 0.64 (0.41 to 1.01) |
| APR (95% CI)             | -                             | Referent                      | Referent                      | 0.64 (0.41 to 1.01) | 0.64 (0.41 to 1.01) |
| Sex                      |                               |                               |                               |                     |                     |
| Women                    | 1896                          | 3682                          | 2895                          | 0.29 (0.21 to 0.39) | 0.64 (0.41 to 1.01) |
| Men                      | 1087                          | 1366                          | 1170                          | 0.20 (0.11 to 0.35) | 0.66 (0.27 to 1.59) |
| Age group (years)        |                               |                               |                               |                     |                     |
| 15 to 24                 | 1181                          | 1927                          | 1835                          | 0.32 (0.19 to 0.53) | 0.64 (0.41 to 1.01) |
| 25 to 44                 | 1255                          | 2091                          | 1835                          | 0.32 (0.19 to 0.53) | 0.64 (0.41 to 1.01) |
| 45 to 59                 | 547                           | 1030                          | 730                           | 0.30 (0.21 to 0.43) | 0.66 (0.27 to 1.59) |
| Residence                |                               |                               |                               |                     |                     |
| Chokwè town              | 1385                          | 1840                          | 1587                          | 0.22 (0.14 to 0.35) | 0.64 (0.41 to 1.01) |
| District villages        | 1598                          | 3208                          | 2478                          | 0.22 (0.14 to 0.35) | 0.64 (0.41 to 1.01) |
| Sexual partners          |                               |                               |                               |                     |                     |
| in past 12 months        |                               |                               |                               |                     |                     |
| 0                        | 461                           | 1040                          | 1028                          | 0.12 (0.05 to 0.32) | 0.90 (0.24 to 3.34) |
| 1                        | 1747                          | 3195                          | 2806                          | 0.12 (0.05 to 0.32) | 0.90 (0.24 to 3.34) |
| 2                        | 772                           | 801                           | 229                           | 0.15 (0.10 to 0.24) | 0.90 (0.24 to 3.34) |
| Condom use in past 12 months |                   |                               |                               |                     |                     |
| No partners/always       | 616                           | 1055                          | 1073                          | 0.26 (0.08 to 0.87) | 0.82 (0.19 to 3.55) |
| Sometimes/never          | 2363                          | 3925                          | 2970                          | 0.26 (0.08 to 0.87) | 0.82 (0.19 to 3.55) |
| Alcohol in past 3 months |                               |                               |                               |                     |                     |
| Never/monthly           | 2570                          | 4488                          | 3788                          | 0.26 (0.19 to 0.35) | 0.76 (0.48 to 1.23) |
| Daily/weekly             | 398                           | 517                           | 262                           | 0.26 (0.19 to 0.35) | 0.76 (0.48 to 1.23) |
| Prior HIV test           |                               |                               |                               |                     |                     |
| <1 year                  | 1100                          | 1972                          | 2379                          | 0.21 (0.12 to 0.36) | 0.91 (0.45 to 1.82) |
| 1 to 4 years             | 911                           | 2484                          | 1174                          | 0.24 (0.16 to 0.38) | 0.89 (0.44 to 1.83) |
| ≥5 years/no test         | 895                           | 535                           | 470                           | 0.53 (0.32 to 0.88) | 0.29 (0.10 to 0.89) |

CI, confidence interval; APR, adjusted prevalence ratio; PR, prevalence ratio.

*Prior diagnostic status of five participants is unknown.**Of all survey participants. Undiagnosed HIV infection = not meeting any of the following conditions: (1) reporting having tested HIV positive previously to standard interview questions, (2) having tested HIV positive at home in a prior round, and (3) having an HIV-1 RNA concentration <1000 copies/mL. Prevalence of undiagnosed HIV infection was estimated using SURVEYFREQ, weighted to the CHDSS census population by age group, sex, and urban (Chokwè town) or rural (CHDSS villages) residence, and adjusted for within-household correlation (SAS, version 9.4, SAS Institute).**All PRs and APRs were weighted to the CHDSS census population by age group, sex, and urban (Chokwè town) or rural (CHDSS villages) residence, and adjusted for within-household correlation using GENMOD (SAS, version 9.4, SAS Institute). GENMOD APRs also adjusted for age group and sex. All PRs and APRs with a lower bound of the 95% CI ≥1.0 are statistically significant (p < 0.05).
5 | CONCLUSIONS

After achieving >90% diagnostic coverage in CHDSS, the prevalence of undiagnosed HIV infection was not statistically significantly reduced with additional rounds of HBHTS. Our findings suggest that sub-Saharan African countries should consider implementing 1 to 2 rounds of HBHTS in underserved high-burden communities that have not yet met the UNAIDS 2030 diagnostic coverage target. The United States President’s Emergency Plan for AIDS Relief supports door-to-door HBHTS for high-burden communities with <70% ART coverage [24]. To increase cost-effectiveness, HIV testing programmes should consider implementing HBHTS with effective linkage services in close collaboration with DREAMS and VMMC prevention programmes, and to the extent possible, with programmes controlling other high-priority diseases.

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COMPETING INTERESTS

The authors have declared no conflict of interest.

AUTHORS’ CONTRIBUTIONS

DM, IC, RN, RT, SP, and SW (alphabetical order) designed and wrote the study protocol and data collection tools. AV, DM, IC, IP, RT, and SW (alphabetical order) acquired funding for the study, and AJ, IC, IM, JB, KH, RT, ST, and VC (alphabetical order) administered the project resources or participant healthcare services. AJ, IC, JB, JC, and RT (alphabetical order) supervised study staff, and DU, IC, and RN (alphabetical order) oversaw data management. RN and SP (alphabetical order) conducted statistical analyses and sample size calculations. DM wrote the first draft of the manuscript, and all authors contributed to and approved the final version of the manuscript for submission.

ETHICAL APPROVAL

The study protocol was approved by the CHDSS community advisory board, the National AIDS Control Program of the Mozambique Ministry of Health, and the Mozambique National Committee for Bioethics. The study was also reviewed and approved in accordance with CDC human research protection procedures. All residents who tested for HIV and participated in interviews provided written informed consent. Consent forms were administered in Shangaan or Portuguese. HBHTS was provided to all consenting household members including children with parental consent; however, data collection was restricted to residents aged 15 to 59 years in accordance with human subjects’ research approvals.

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