Routine programmatic data show a positive population-level impact of HIV self-testing: the case of Côte d'Ivoire and implications for implementation

Short title: Assessing impact of HIV self-testing

Arlette Simo Fotso[a,b§], Cheryl Johnson[c], Anthony Vautier[d], Konan Blaise Kouamé[e], Papa Moussa Diop[d], Romain Silhol[f], Mathieu Maheu-Giroux[g], Marie-Claude Boily[f], Nicolas Rouveau[a], Clémence Doumenc-Aïdara[d], Rachel Baggaley[c], Eboi Ehui[e], Joseph Larmarange[a] for the ATLAS team[h]

Affiliations:

[a]Centre Population & Développement, Université de Paris, IRD, Inserm, Paris, France
[b]French Institute for Demographic Studies, INED, Aubervilliers, France
[c]World Health Organization, Geneva, Switzerland
[d]Solidarité Thérapeutique et Initiatives pour la Santé, Solthis, Dakar, Sénégal
[e]Programme National de Lutte contre le Sida, Abidjan, Côte d'Ivoire
[f]Medical Research Council Centre for Global Infectious Disease Analysis, School of Public Health, Imperial College London, London, United Kingdom
[g]Department of Epidemiology and Biostatistics, School of Population and Global Health, McGill University, Montréal, QC, H3A 1G1, Canada
[h]Full composition of the ATLAS Team provided in the Supplementary Materials

ORCID & emails:

- ASF (PhD): 0000-0002-5006-8105, arlette.simofotso@ird.fr, CEPED 45 rue des Saint Père, Paris, France
- CJ (MA): 0000-0001-5499-5523, johnsonc@who.int, WHO Geneva
- AV (MPH): 0000-0001-8039-6479, directeurtech.ATLAS@solthis.org, Solthis 36, rue OKM 31, Cité Mamelles, Ouakam, Dakar, Sénégal
- KBK (MD): +225 0708047279, kouame.blaise@pnls-ci.com, Côte d'Ivoire
- PMD (DEA): 0000-0003-2315-0258, coordinateurm_e.atlas@solthis.org, Solthis 36, rue OKM 31, Cité Mamelles Ouakam, Dakar, Sénégal
- RS (PhD): 0000-0002-5750-7609, r.silhol@imperial.ac.uk, MRC Centre for Global Infectious Disease Analysis, Department of Infectious Disease Epidemiology, Imperial College London, St Mary's Hospital, 2 Norfolk Place, W2 1PG London, United Kingdom
- MMG (ScD): 0000-0002-8363-4388, mathieu.maheu-giroux@mcgill.ca, 2001 Avenue McGill Collège, Suite 1200, Montréal, Québec, H3A, 1G1 Canada
- MCB (PhD): 0000-0003-3919-006X, mc.boily@ic.ac.uk, School of Public Health, Medical School Building, St. Mary's Hospital, Norfolk Place, London W2 1PG, United Kingdom
- NR (PharmD): 0000-0002-5621-4230, nicolas.rouveau@ceped.org, CEPED 45 rue des Saint Père, Paris, France

- CD (MEcon): 0000-0001-9595-2095, directriceprojet.atlas@solthis.org, Solthis 36, rue OKM 31, Cité Mamelles Ouakam, Dakar, Sénégal
- RB (MBBS) : 0000-0001-6320-3444, baggaleyr@who.int, WHO Geneva
- EE (PhD): ehui.eboi@pnls-ci.com
- JL (PhD): 0000-0001-7097-700X, joseph.larmarange@ird.fr, CEPED 45 rue des Saint Père, Paris, France

§ **corresponding author:** Arlette Simo Fotso, Address: CEPED, 45 Rue des Saint Père, 75006, Paris, France

Tel: +33(0) 622449606,

Email; simofotsoarlette@yahoo.fr

Abstract

Objectives: We estimate the effects of ATLAS's HIVST kit distribution on conventional HIV testing, diagnoses, and antiretroviral treatment (ART) initiations in Côte d'Ivoire.

Design: Ecological study using routinely collected HIV testing services program data.

Methods: We used the ATLAS's programmatic data recorded between the third quarter of 2019 and the first quarter of 2021, in addition to data from the President's Emergency Plan for AIDS Relief dashboard. We performed ecological time series regression using linear mixed models. Results are presented per 1,000 HIVST kits distributed through ATLAS.

Results: We found a negative but nonsignificant effect of the number of ATLAS' distributed HIVST kits on conventional testing uptake (-190 conventional tests; 95%CI: -427 to 37). The relationship between the number of HIVST kits and HIV diagnoses was significant and positive (+8 diagnosis; 95%CI: 0 to 15). No effect was observed on ART initiation (-2 ART initiations; 95%CI: -8 to 5).

Conclusions: ATLAS' HIVST kit distribution had a positive impact on HIV diagnoses. Despite the negative signal on conventional testing, even if only 20% of distributed kits are used, HIVST would increase access to testing. The methodology used in this paper offers a promising way to leverage routinely collected programmatic data to estimate the effects of HIVST kit distribution in real-world programs.

Keywords: HIV self-testing; testing; diagnosis; antiretroviral treatment; triangulation of programmatic data; implementation; key populations; female sex workers; men who have sex with men.

Introduction

In 2019, up to 19% of people with HIV (PWHIV) worldwide were not aware of their HIV status [1]. In Western Africa, this proportion of undiagnosed PWHIV reached 33% in 2020 [2]. This is well below the *Joint United Nations Programme on HIV/AIDS* (UNAIDS) target to achieve less than 5% of PWHIV being undiagnosed by 2025. HIV testing is a crucial element of responses to HIV, as it is the first step to linkage to care and treatment. HIV testing is also key for prevention, as PWHIV on antiretroviral treatment (ART) and virally suppressed will not transmit HIV to their sexual partners [3].

The World Health Organization (WHO) recommends HIV self-testing (HIVST), which allows individuals to test themselves and learn their results when and how they want [4]. It is an innovative tool that has been demonstrated to be safe, accurate, empowering, and acceptable and to also consistently increase the uptake and frequency of HIV testing across settings and populations [5–12]. It is recommended that a reactive HIVST must be followed by a conventional test to confirm or disprove the results.

In Southern and East Africa, HIVST has been scaled up quickly, catalyzed by the Unitaid-funded Self-test Africa (STAR) initiative, which was started in 2015 [13]. However, before 2019, HIVST was offered only in West Africa through small-case pilot projects [14]. A medium-scale HIVST program was implemented in Côte d'Ivoire, Mali, and Senegal in 2018, with an effective distribution of kits through the ATLAS project funded by Unitaid and implemented by a consortium led by *Solidarité thérapeutique et initiatives pour la santé* (Solthis) and the French Research Institute for Sustainable Development (IRD) since 2019 [15]. From 2019-2022, together with national programs, ATLAS planned to deliver 400 000 HIVST kits (214 000 in Côte d'Ivoire). The ATLAS program had set a target for 90% of HIVST implementation to reach key populations (KPs) and their sexual partners, peers and clients. In West Africa the epidemic remains concentrated in KPs, such as female sex workers (FSW), men who have sex with men (MSM), and people who use drugs (PWUD); and is partly drawn by some vulnerable group such as clients of FSW and their non-FSW female partners [16–18]. The remaining priority populations of the ATLAS HIVST implementation were people with sexually transmitted infections (STIs), their partners and partners of people living with HIV.

ATLAS activities rely on both primary and secondary distribution channels. With primary distribution, HIVST kits are distributed by peer educators and frontline health care workers to primary contacts—MSM, PWHIV, STI patients, FSW, and PWUD—for their personal use. For secondary distribution, primary contacts are invited to redistribute HIVST kits to their peers, partners, clients and relatives. These secondary contacts are often members of key and vulnerable populations who often do not have easy access to the health system, including sexual partners of PWHIV or members of KPs. This specificity of HIVST kit distribution implies that HIVST beneficiaries (end-users) are not limited to primary contacts. ATLAS's program results have shown that HIVST can reduce stigma; preserve anonymity and confidentiality; reach KPs that do not access testing via other testing approaches; save opportunity costs for users and providers; empower users with autonomy and responsibility; and is noninvasive and easy to use [19–22].

Several programs have developed methods to assess the use of HIVST and test results, such as supervision by health workers, the return of used kits, messages or phone call reminders to return used samples, the electronic transmission of photographs of test results, or the use of Bluetooth sensors [23]. However, such tracking can be costly and counterproductive by limiting the use and distribution of HIVST and is not in line with the philosophy of HIVST, where users can anonymously decide when and where they are tested and if and to whom they want to report their results. The systematic tracking of HIVST through secondary distribution is logistically challenging and can also hinder the secondary distribution of HIVST, as primary contacts can be reluctant to redistribute an HIVST kit if they need to collect contact information. It could also be challenging for tracking HIVST at a large scale due to the logistics it might involve. To preserve the anonymity and confidentiality of those using HIVST and not impede the use of HIVST, ATLAS decided not to systematically track distributed HIVST kits. Nevertheless, HIVST users can still, if they wish, obtain additional support by calling a peer educator or a national HIV hotline.

Without systematic and direct feedback regarding the use and results of HIVST and linkage to confirmatory testing and ART, it is challenging to estimate the population-level impacts of HIVST distribution [24]. In this paper, we aimed to circumvent this problem by using routinely collected programmatic data to estimate the effects of ATLAS's HIVST distribution on conventional HIV testing (i.e., self-testing excluded), HIV diagnoses, and ART initiations in Côte d'Ivoire.

Methods

Data sources

ATLAS HIVST distribution in Côte d'Ivoire started during the third quarter of 2019 (Q3 2019) among individuals aged 16 years or older (minimum legal age for HIV testing without parental consent). All ATLAS implementing partners reported the number of HIVST kits distributed through ATLAS monthly by distribution site, delivery channel, age group and sex of primary contacts. Data were aggregated per health district and quarter of the year. In 2020, Côte d'Ivoire was divided into 33 health regions and 113 health districts.

Routine programmatic data for adults over 15 years of age were obtained from the *President's Emergency Plan for AIDS Relief (*PEPFAR) open-access public repository (https://data.pepfar.gov/). PEPFAR is the principal donor to the national AIDS program in Côte d'Ivoire. It collects programmatic data in the health districts where it intervenes, including (i) the number of HIVST kits distributed through PEPFAR-funded activities; (ii) conventional testing (i.e., the number of "*individuals tested for HIV who received results*"); (iii) HIV diagnoses (i.e., the number of "*individuals who newly tested positive for HIV*"); and (iv) ART initiations (i.e., the number of "*people newly enrolled to receive ART*").

For this study, we used these two sources of quarterly data aggregated at the health district level —harmonized according to the 2020 subdivision— from Q3 2019 to Q1 2021. Over this period, the PEPFAR data were only available for 78/113 (69%) Ivorian health districts. Only these districts were included in the analysis.

This study does not raise any ethical concern, as the data used are aggregated and completely anonymized. A secondary analysis of the ATLAS programmatic data is included in the associated research protocol approved by the WHO Ethical Research Committee, the National Ethics Committee for Life Sciences and Health of Côte d'Ivoire, the Ethics Committee of the Faculty of Medicine and Pharmacy of the University of Bamako, and the National Ethics Committee for Health Research of Senegal.

Modeling strategy

Our analysis considered three outcomes: the number of conventional HIV tests, HIV diagnoses, and ART initiations. These three outcomes were obtained directly from the PEPFAR datasets.

We used ecological time series regression to model the linear effect of the number of HIVST kits distributed through ATLAS for each outcome [25]. We first used linear mixed models with district-level random effects, as presented in Equation (1):

$$E[y_{i,t}] = \beta_1 \cdot HIVST_{i,t} + \beta_2 \cdot T_t + d_i \qquad (1)$$

Where $y_{i,t}$ is the outcome of district i at time t. $HIVST$ is the number of HIVST kits distributed through ATLAS for district i at time t. β_1 represents the effect of the latter variable on the outcomes. T_t is calendar time, which captures conjectural effects in vector β_2. Conjectural effects were modeled as a categorical variable of the quarter of the year to account for any nonlinear or nonpolynomial trend [26]. Modeling time as a categorical variable is also equivalent to running a time fixed-effects model, which allows controlling for variables that are constant across districts but vary over time such as shocks that might occur over the time. d_i is the district-specific random effect. District-level random effects were used to account for autocorrelation due to multiple observations and to produce standard errors adjusted for clustering.

Then, contextual effects were also taken into account by introducing the categorical variable of health regions (R_i), and related vector of coefficients β_3, in the model defined by Equation (2):

$$E[y_{i,t}] = \beta_1 \cdot HIVST_{i,t} + \beta_2 \cdot T_t + \beta_3 \cdot R_i + d_i \qquad (2)$$

For each outcome, both Models (1) and (2) were run and results are presented in in supplementary materials, http://links.lww.com/QAD/C586.

ATLAS activities were implemented in 9 of the 78 districts covered by the PEPFAR dataset. We performed a sensitivity analysis by restricting the sample to these 9 health districts. In addition, we assessed the robustness of our results by using cubic splines instead of a categorical variable for modeling time and compared the AIC (Akaike information criterion) of the models.

All analyses were performed in R (version 4.0.3) using the "*lme4*" package for statistical models [27].

Results

Descriptive statistics

In the 78 health districts monitored by PEPFAR, between Q3 2019 and Q1 2021, 30 781 HIVTS kits were distributed through PEPFAR, and 99 353 HIVST kits were distributed through ATLAS, compared with 2 167 828 conventional tests performed over the same period (Table 1). High disparities in terms of volume were observed between districts, with a minimum of 1 832 conventional tests and a maximum of 139 214 (median of 13 348). The 9 districts —out of 78 where ATLAS activities were implemented— accounted for one quarter (532 287/2 167 828) of conventional tests. Important variations were observed in terms of HIV diagnoses, and ART initiations across districts. In the 78 districts included in the analysis, conventional testing decreased between Q3 2019 and Q1 2021, from 379 554 individuals tested for HIV who received their results in Q3 2019 to 268 807 in Q1 2021 (Figure 1a). In the 69 districts that were not covered by ATLAS (Figure 1c), HIVST kits distributed through PEPFAR remained limited and largely insufficient to compensate for the reduction in conventional testing; only 13% of the tests in these districts were HIVST kits. In the 9 ATLAS districts, HIVST kit distribution —mainly through ATLAS, but also partially through PEPFAR— has increased continuously since Q3 2019 (Figure 1b), with a slow-down in Q2 2020, when governmental COVID-19 measures were introduced. Overall, the shock caused by the COVID-19 pandemic is observed in Q2 2020.

HIV diagnoses and ART initiations remained relatively stable over time (Figures 2a & 2b), with a catch-up effect observed in Q1 2020 after a slowdown in Q4 2019. Trends were similar in the ATLAS districts and the districts not covered by ATLAS.

Regression results

When adjusting for time and region (first columns of Table 2), the estimated effect of ATLAS HIVST kit distribution shows a non-significant negative signal on conventional testing, with a decline of -195 [95%CI: -427 to 38, p=0.10] conventional tests for every 1000 additional HIVST kits distributed by ATLAS. HIVST kit distribution was positively associated with HIV diagnoses: +8 diagnoses [95%CI: 0 to 15, p=0.04] per 1000 additional HIVST kits distributed. No association between HSVST kit distribution and ART initiations was observed: -2 [95%CI: -8 to 5, p=0.66]. Similar results were observed when adjusting only for time regarding the linear effect of the number of HIVST kits distributed through ATLAS on the different outcomes (first columns of Table A1, Table A2 and Table A3). Full regression tables are presented in the second columns of Table A1, Table A2 and Table A3.

When restricting the analyses to the 9 ATLAS districts, the estimated magnitudes of association were larger, though not statistically significant (second columns of Table 2). The sensitivity analyses modeling time with cubic splines instead of categorical variables showed very similar results (Table A4). However, the effect on HIV diagnoses was no longer significant. A comparison of the AIC values of the models indicated that the models with categorical variables fit the time series better (Table A5).

Discussion

Using routinely collected programmatic data aggregated quarterly at the health district level, our analyses showed a significant positive effect of HIVST kits distributed through ATLAS on HIV diagnoses. Our results suggested a possible negative signal, albeit not statistically significant, on conventional testing, and no observable effect on the most distal outcome of ART initiations.

HIVST could lead to some substitution effects if HIVST kits are used by individuals who would have undergone a conventional HIV test in their absence, as observed in other studies [5,28]. Such effects may be concerning for policy-makers, as gains in HIV testing coverage due to HIVST distribution may result in a reduction in the number of conventional HIV tests. Our results did show a negative effect of HIVST kit distribution on conventional testing (-195 conventional tests for every 1000 distributed HIVST) but the uncertainty was large and we cannot rule out the absence of substitution effects. However, even if this substitution effect was significant and that only 20% of distributed HIVST kits were used, the net impact on testing uptake would be positive: 200 additional HIVST performed for every 1000 distributed HIVST would reduce the number of conventional tests by 195 (net impact of +5). The existing literature reports utilization rate of HIVST that could reach up to 80% [29], suggesting our 20% utilization rate assumption is conservative. Moreover, the descriptive data showed that a decrease in conventional testing occurred in all districts, including those not covered by ATLAS activities, this is linked to the fact that PEPFAR's testing strategies are revised annually and favoring more targeted approaches [30]. Our results suggest that ATLAS HIVST distribution help maintain access to HIV testing in its implementation districts despite the slowdown observed in Q2 2020 when governmental COVID-19 measures were introduced. In fact, a main takeaway from the ATLAS project is that HIVST distribution activities among KPs can be easily adapted, including in the context of the COVID-19 pandemic [21].

Due to its confidential nature, HIVST could overcome several structural barriers for HIV diagnoses —such as stigma and opportunity costs— and create new approaches to reach first-time testers and boost HIV retesting for KPs, therefore improving access to HIV testing overall. These results are in line with previous studies among KPs in East and South Africa [5,28,31].

If HIVST is appropriately used as a triage test and individuals with reactive self-tests are linked for confirmatory testing, HIVST distribution activities should lead to a higher number of positive tests in conventional testing. Several actors have expressed concern that HIVST could have a negative impact on new diagnoses [32]. In fact, at the beginning of the ATLAS project, key stakeholders, though recognizing the potential of HIVST to reach first-time testers, expressed some doubts regarding users' ability to accept a reactive test result. There were concerns that individuals with reactive tests would not seek confirmatory testing, which would limit the number of new diagnosed observed at health facilities [19]. Our results did not show any deleterious effect on HIV diagnoses but rather showed a significant positive effect. For the 99 353 HIVST distributed through ATLAS over the period Q3 2019 through Q1 2021, this could translate to 795 additional diagnoses. This is in line with some other studies, such as that by MacGowan *et al.*, who found that the number of HIV infections detected in their HIVST

arm was higher compared to the control arm in a randomized trial conducted among MSM [33].

Our model did not observe any effect of ATLAS HIVST kit distribution on ART initiations. The estimated effect was negative when all 78 districts were included and positive when the analysis was limited to the 9 ATLAS districts. The analysis with 9 districts could suffer from a lack of power. However, in all instances, the effect size estimate was small. The PEPFAR datasets are not exhaustive for Côte d'Ivoire and cover only 78 out of the 113 health districts at the national level and 9 of the 12 ATLAS districts.

Using aggregated data rather than individual data implies a lower number of observation points and therefore lower statistical power, although these data allow us to make population-level estimates. Aggregated data is subject to ecological bias and statistical relationships must be interpreted with caution. In addition, it is not possible to completely rule out any 'contamination' effect, as individuals living on district borders could perform conventional testing in the neighboring district. However, we could assume that population movement at boundaries could happen in both directions, thus compensating for each other, or expect the observed effect to have been even stronger without a 'contamination' effect. The collected data did not allow us to distinguish between confirmatory tests following HIVST and classic conventional tests, but as the HIV prevalence is relatively low in the country, the former number might not be important. Finally, HIVST kits distributed through UNICEF or the Global Fund to fight AIDS, tuberculosis and malaria at district level and by yearly quarter are not available. Nevertheless, the volumes of tests distributed by these programs were very low, 6 879 and 1 373 kits, respectively, by 2020, representing less than 7% of all HIVST kits distributed in the country.

A strength of this study is that it specifically used only indicators that had already been routinely collected by countries, which means that the method could be easily replicated in other contexts and used by other countries to monitor the impact of their HIVST activities without any additional cost. Our analysis did not rely on any systematic tracking system or data collection process, which can be expensive and complex and are counter to the rationale for HIVST.

A core component of the ATLAS HIVST strategy in West Africa is the secondary distribution of HIVST kits, primarily distributed through activities targeting individuals in KPs, in particular FSW and MSM. It is therefore expected that many HIVST users would not self-identify as being in a KP and that those with a reactive test would not link to partner community facilities serving KPs for confirmatory testing but rather to more general public or private facilities, making it difficult to link specific records with the distribution of HIVST kits. In addition, records of prior HIVST kit use at health facilities are expected to be underestimated, as recognizing such use would mean the individual was a member of and/or in a network of a KP. By using data aggregated at the district level and covering all testing facilities, confirmatory tests prompted by reactive HIVST results are considered, regardless of where they occurred. By allowing programs to shift from systematic tracking for evaluation, such indirect evaluation would help to focus on and increase access to HIV testing for hard-to-reach populations and first-time testers and allow large-scale secondary distribution implementation.

Conclusions

To the best of our knowledge, this represents the first study estimating the impact of HIVST kit distribution at the population level in West Africa. Our results highlight that a social network-based HIVST distribution strategy, focusing on key population members as primary contacts but aiming to reach their partners and social contacts, does have a positive impact on diagnoses that is observable at the population level.

Such evaluation is pragmatic and could be performed with routinely collected programmatic indicators. The WHO recommends reporting on the number of HIVST kits distributed and estimating HIVST access and use through population-based surveys. Countries are burdened with multiple HIV reporting systems and numerous indicators. It could therefore be of considerable benefit to monitor the impact of self-testing through current data systems without introducing new indicators and further data collection. This method of triangulating available data provides further information on the population-level impacts of HIV self-testing to guide program use.

Ethics statement

This study does not raise any ethical concern, as the data used are aggregated and thus completely anonymized.

A secondary analysis of the ATLAS programmatic data is included in the associated research protocol available at https://atlas.solthis.org/en/research/. This protocol (version 2.1, August 5 2019) was approved by the WHO Ethical Research Committee (August 7 2019, Reference: ERC 0003181), the National Ethics Committee for Life Sciences and Health of Côte d'Ivoire (May 28 2019, Reference: 049-19/MSHP/CNESVS-kp), the Ethics Committee of the Faculty of Medicine and Pharmacy of the University of Bamako, Mali (August 14 2019, Reference: 2019/88/CE/FMPOS), and the National Ethics Committee for Health Research of Senegal (July 26 2019, Protocol SEN19/32).

References

1. UNAIDS. 90–90–90: good progress, but the world is off-track for hitting the 2020 targets [Internet]. 2020 [cited 2021 Nov 15]. Available from: https://www.unaids.org/en/resources/presscentre/featurestories/2020/september/20200921 _90-90-90

2. Giguère K, Eaton JW, Marsh K, Johnson LF, Johnson CC, Ehui E, et al. Trends in knowledge of HIV status and efficiency of HIV testing services in Sub-Saharan Africa (2000-2020): a modelling study of survey and HIV testing program data. medRxiv. Cold Spring Harbor Laboratory Press; 2020;2020.10.20.20216283.

3. Li Z. Vital Signs: HIV Transmission Along the Continuum of Care — United States, 2016. MMWR Morb Mortal Wkly Rep [Internet]. 2019 [cited 2021 Jun 8];68. Available from: https://www.cdc.gov/mmwr/volumes/68/wr/mm6811e1.htm

4. World Health Organization. Guidelines on HIV self-testing and partner notification: supplement to Consolidated guidelines on HIV testing services. 2016.

5. Chanda MM, Ortblad KF, Mwale M, Chongo S, Kanchele C, Kamungoma N, et al. HIV self-testing among female sex workers in Zambia: A cluster randomized controlled trial. PLoS Med. 2017;14:e1002442.

6. Figueroa C, Johnson C, Ford N, Sands A, Dalal S, Meurant R, et al. Reliability of HIV rapid diagnostic tests for self-testing compared with testing by health-care workers: a systematic review and meta-analysis. Lancet HIV. 2018;5:e277–90.

7. Johnson C, Baggaley R, Forsythe S, van Rooyen H, Ford N, Napierala Mavedzenge S, et al. Realizing the potential for HIV self-testing. AIDS Behav. 2014;18 Suppl 4:S391-395.

8. Knight L, Makusha T, Lim J, Peck R, Taegtmeyer M, van Rooyen H. "I think it is right": a qualitative exploration of the acceptability and desired future use of oral swab and finger-prick HIV self-tests by lay users in KwaZulu-Natal, South Africa. BMC Res Notes. 2017;10.

9. Kurth AE, Cleland CM, Chhun N, Sidle JE, Were E, Naanyu V, et al. Accuracy and Acceptability of Oral Fluid HIV Self-Testing in a General Adult Population in Kenya. AIDS Behav. 2016;20:870–9.

10. Njau B, Covin C, Lisasi E, Damian D, Mushi D, Boulle A, et al. A systematic review of qualitative evidence on factors enabling and deterring uptake of HIV self-testing in Africa. BMC Public Health. 2019;19:1289.

11. Oldenburg CE, Ortblad KF, Chanda MM, Mwale M, Chongo S, Kanchele C, et al. Intimate Partner Violence and Antiretroviral Therapy Initiation Among Female Sex Workers Newly Diagnosed With HIV in Zambia: A Prospective Study. J Acquir Immune Defic Syndr. 2018;79:5.

12. Thirumurthy H, Masters SH, Mavedzenge SN, Maman S, Omanga E, Agot K. Promoting male partner HIV testing and safer sexual decision making through secondary distribution

of self-tests by HIV-negative female sex workers and women receiving antenatal and post-partum care in Kenya: a cohort study. Lancet HIV. 2016;3:e266–74.

13. Ingold H, Mwerinde O, Ross AL, Leach R, Corbett EL, Hatzold K, et al. The Self-Testing AfRica (STAR) Initiative: accelerating global access and scale-up of HIV self-testing. J Int AIDS Soc. 2019;22:e25249.

14. Lyons CE, Coly K, Bowring AL, Liestman B, Diouf D, Wong VJ, et al. Use and Acceptability of HIV Self-Testing Among First-Time Testers at Risk for HIV in Senegal. AIDS Behav [Internet]. 2019 [cited 2021 Mar 25];23:130–41. Available from: http://link.springer.com/10.1007/s10461-019-02552-2

15. Rouveau N, Ky-Zerbo O, Boye S, Fotso AS, d'Elbée M, Maheu-Giroux M, et al. Describing, analysing and understanding the effects of the introduction of HIV self-testing in West Africa through the ATLAS programme in Côte d'Ivoire, Mali and Senegal. BMC Public Health. 2021;21:181.

16. UNAIDS. UNAIDS data 2020 [Internet]. USA: UNAIDS; 2020 p. 436. Available from: https://www.unaids.org/en/resources/documents/2020/unaids-data

17. Avert. HIV and AIDS in East and Southern Africa regional overview [Internet]. Avert. 2015 [cited 2022 Jan 12]. Available from: https://www.avert.org/professionals/hiv-around-world/sub-saharan-africa/overview

18. Maheu-Giroux M, Vesga JF, Diabaté S, Alary M, Baral S, Diouf D, et al. Changing Dynamics of HIV Transmission in Côte d'Ivoire: Modeling Who Acquired and Transmitted Infections and Estimating the Impact of Past HIV Interventions (1976–2015). JAIDS J Acquir Immune Defic Syndr. 2017;75:517–27.

19. Ky-Zerbo O, Desclaux A, Kouadio AB, Rouveau N, Vautier A, Sow S, et al. Enthusiasm for Introducing and Integrating HIV Self-Testing but Doubts About Users: A Baseline Qualitative Analysis of Key Stakeholders' Attitudes and Perceptions in Côte d'Ivoire, Mali and Senegal. Front Public Health [Internet]. 2021 [cited 2021 Oct 18];9. Available from: https://www.frontiersin.org/article/10.3389/fpubh.2021.653481

20. Boye S, Bouaré S, Ky-Zerbo O, Rouveau N, Simo Fotso A, d'Elbée M, et al. Challenges of HIV Self-Test Distribution for Index Testing When HIV Status Disclosure Is Low: Preliminary Results of a Qualitative Study in Bamako (Mali) as Part of the ATLAS Project. Front Public Health [Internet]. Frontiers; 2021 [cited 2021 Jul 12];9. Available from: https://www.frontiersin.org/articles/10.3389/fpubh.2021.653543/full

21. Kra AK, Colin G, Diop PM, Fotso AS, Rouveau N, Hervé KK, et al. Introducing and Implementing HIV Self-Testing in Côte d'Ivoire, Mali, and Senegal: What Can We Learn From ATLAS Project Activity Reports in the Context of the COVID-19 Crisis? Front Public Health. Frontiers; 2021;1–14.

22. d'Elbée M, Traore MM, Badiane K, Vautier A, Simo Fotso A, Kabemba OK, et al. Costs and Scale-Up Costs of Integrating HIV Self-Testing Into Civil Society Organisation-Led Programmes for Key Populations in Côte d'Ivoire, Senegal, and Mali. Front Public Health

[Internet]. Frontiers; 2021 [cited 2021 Jul 12];9. Available from: https://www.frontiersin.org/articles/10.3389/fpubh.2021.653612/full

23. Tahlil KM, Ong JJ, Rosenberg NE, Tang W, Conserve DF, Nkengasong S, et al. Verification of HIV Self-Testing Use and Results: A Global Systematic Review. AIDS Patient Care STDs. 2020;34:147–56.

24. Choko AT, Jamil MS, MacPherson P, Corbett E, Chitembo L, Ingold H, et al. Measuring linkage to HIV treatment services following HIV self-testing in low-income settings. J Int AIDS Soc [Internet]. 2020 [cited 2021 Jun 18];23. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7314400/

25. Bhaskaran K, Hajat S, Haines A, Herrett E, Wilkinson P, Smeeth L. Short term effects of temperature on risk of myocardial infarction in England and Wales: time series regression analysis of the Myocardial Ischaemia National Audit Project (MINAP) registry. BMJ. British Medical Journal Publishing Group; 2010;341:c3823.

26. Bhaskaran K, Gasparrini A, Hajat S, Smeeth L, Armstrong B. Time series regression studies in environmental epidemiology. Int J Epidemiol. 2013;42:1187–95.

27. Bates D, Mächler M, Bolker B, Walker S. Fitting Linear Mixed-Effects Models Using lme4. J Stat Softw. 2015;67:1–48.

28. Ortblad K, Kibuuka Musoke D, Ngabirano T, Nakitende A, Magoola J, Kayiira P, et al. Direct provision versus facility collection of HIV self-tests among female sex workers in Uganda: A cluster-randomized controlled health systems trial. PLoS Med. 2017;14:e1002458.

29. Choko AT, MacPherson P, Webb EL, Willey BA, Feasy H, Sambakunsi R, et al. Uptake, Accuracy, Safety, and Linkage into Care over Two Years of Promoting Annual Self-Testing for HIV in Blantyre, Malawi: A Community-Based Prospective Study. PLoS Med. 2015;12:e1001873.

30. Bekelynck A, Larmarange J, ANRS 12323 DOD-CI Study Group. Pepfar 3.0's HIV testing policy in Côte d'Ivoire (2014 to 2018): fragmentation, acceleration and disconnection. J Int AIDS Soc. 2019;22:e25424.

31. Kelvin EA, George G, Mwai E, Kinyanjui S, Romo ML, Odhiambo JO, et al. A Randomized Controlled Trial to Increase HIV Testing Demand Among Female Sex Workers in Kenya Through Announcing the Availability of HIV Self-testing Via Text Message. AIDS Behav. 2019;23:116–25.

32. Ky-Zerbo O. "When you provide an HIV self-testing kit […] you also need to know the results": lay providers' concerns on HIV self-testing provision to peers, ATLAS project. 2020.

33. MacGowan RJ, Chavez PR, Borkowf CB, Owen SM, Purcell DW, Mermin JH, et al. Effect of Internet-Distributed HIV Self-tests on HIV Diagnosis and Behavioral Outcomes in Men Who Have Sex With Men: A Randomized Clinical Trial. JAMA Intern Med. 2020;180:117–25.

Figure 1: Number of conventional testing and HIVST kits distributed through PEPFAR and ATLAS from Q3 2019 to Q1 2021 in a) all 78 health districts monitored by PEPFAR in Côte d'Ivoire, b) the 9 ATLAS districts only, and c) the 69 districts not covered by ATLAS.
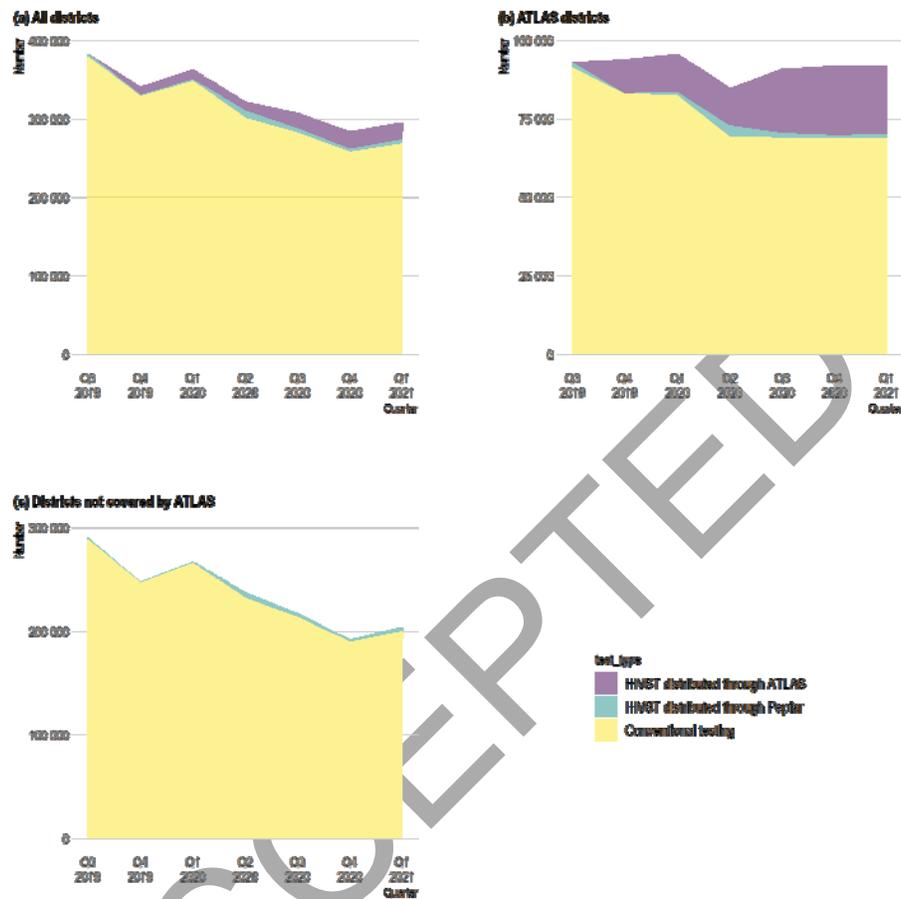

Table 1: District characteristics and activities between Q3 2019 and Q1 2021 in 78 health districts monitored by PEPFAR in Côte d'Ivoire

Variable	All districts, N = 78	ATLAS districts, N = 9	Districts not covered by ATLAS, N = 69
Conventional testing			
sum	2 167 828	532 287	1 635 541
Median	19 348	57 037	18 162
Range	1 832 - 139 214	13 914 - 139 214	1 832 - 78 847
HIV diagnoses			
sum	60 716	16 143	44 573

Variable	All districts, N = 78	ATLAS districts, N = 9	Districts not covered by ATLAS, N = 69
Median	484	1 465	467
Range	33 - 3 862	251 - 3 862	33 - 2 749
ART initiations			
sum	54 354	13 846	40 508
Median	430	1 414	422
Range	33 - 3 068	216 - 3 068	33 - 2 274
HIVST distributed through ATLAS			
sum	99 353	99 353	0
Median	0	10 968	0
Range	0 - 23 472	1 364 - 23 472	0 - 0
HIVST distributed through Pepfar			
sum	30 781	9 881	20 900
Median	168	735	100
Range	0 - 2 536	102 - 2 536	0 - 1 881

Table 2: Linear effect of the number of HIVST kits distributed through ATLAS on access to HIV testing, conventional tests, diagnoses and ART initiations in the health districts monitored by PEPFAR in Côte d'Ivoire (Q3 2019 to Q1 2021)

	All districts			ATLAS districts		
Outcome	Coef.	95% CI[1]	p-value	Coef.	95% CI[1]	p-value
Conventional testing	-195	-427 to 38	0·10	112	-527 to 750	0·73
HIV diagnoses	8	0 to 15	0·04	14	-10 to 38	0·25
ART initiations	-2	-8 to 5	0·66	5	-14 to 25	0·57

[1]CI = Confidence Interval. Coef.= coefficient. For the three outcomes, only the regression coefficients of the number of HIVST kits distributed through ATLAS are presented. Coefficients represent the unit change (e.g., conventional tests, diagnoses, ART initiations) per 1,000 HIVST test kits distributed through ATLAS. For the full regression table, see the Supplementary Material (Table A1 through A3).