HIV COMMUNITY INDEX TESTING REACHES PROPORTIONALLY MORE MEN THAN FACILITY-BASED TESTING AND IS COST-EFFECTIVE: A STUDY FROM GAZA PROVINCE, MOZAMBIQUE

STUDY REPORT
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Acronyms

ADPP	Aid Development from People for People
ART	Antiretroviral therapy
CDC	Centers for Disease Control and Prevention
EGPAF	Elizabeth Glaser Pediatric AIDS Foundation
HIV	Human Immunodeficiency Virus
ICASA	International Conference on AIDS and Sexually Transmitted Infections in Africa
IRB	Institutional Review Board
M&E	Monitoring and Evaluation
MOH	Ministry of Health
PEPFAR	President's Emergency Plan for AIDS Relief
PPOP	Patient and Program Outcomes Protocol
UNAIDS	Joint United Nations Program on HIV/AIDS
US$	United States dollars
WHO	World Health Organization

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Executive Summary

Introduction**:** In Mozambique, 38.7% of women and 60.4% of men ages 15–59 years old living with HIV do not know their HIV status. In eight districts in Gaza province, the Elizabeth Glaser Pediatric AIDS Foundation (EGPAF) co-implemented with Aid for the Development of People for People (ADPP) a home-based HIV counseling and testing based on index cases in the community, which targeted the sexual partners, biological children under 14 years old living in the same household, and parents (for pediatric cases) of people living with HIV. The study aimed to estimate the cost-efficiency and effectiveness of community index testing and compare the HIV testing outputs with facility-based testing.

Methods**:** We collected EGPAF program activity data from internal financial reports and spreadsheets. Program costs included: human resources, HIV rapid tests, travel and transportation for supervision and home visits, training, supplies and consumables, and review and coordination meetings. Costs were estimated from a health systems perspective using a micro-costing approach. All project costs were incurred between October 2017 and September 2018 and converted to U.S. dollars (US$) using the prevailing exchange rate at the time of purchase or payment from Mozambique`s Central Bank. We estimated the cost per individual tested, per new HIV diagnosis, and per infection averted.

Results**:** A total of 91,411 individuals were tested for HIV through community index testing, of which 7,011 were newly diagnosed with HIV. Human resources (52%), purchase of HIV rapid tests (28%) and supplies (8%) were the major cost drivers. The cost per individual tested was $5.82, per new HIV diagnosis was $65.32, and per infection averted was $1,358. Furthermore, the community index testing approach proportionally tested more men (53%) than facility-based testing (27%).

Conclusion: These data suggest that expansion of the community index case approach may be a cost-effective and cost-efficient strategy to increase the identification of previously undiagnosed HIV-positive individuals, particularly men.

Keywords: HIV, index testing, cost efficiency, Mozambique

1. Background

Globally, an estimated 37.7 million people were living with HIV in 2020 of which 10.2 million were not on treatment. and many were unaware of their HIV status (UNAIDS, 2021a). While critical progress has been made in addressing the HIV epidemic, many countries are still not on track to reach the global UNAIDS 95-95-95 targets, which seek to ensure 95% of people living with HIV (PLHIV) know their HIV status, 95% of PLHIV receive antiretroviral therapy (ART) and 95% of those on ART are virally suppressed by 2030.

HIV causes an estimated 38,000 deaths per year in Mozambique (UNAIDS, 2021b). According to 2020 UNAIDS estimates, the prevalence of HIV in the population between ages 15–49 years old is 11.5%, 14.4% in women and 8.6% in men (UNAIDS, 2021b). Of the 2.1 million PLHIV in Mozambique, only 1.4 million are receiving ART (UNAIDS, 2021b). Identification of HIV positive individuals would enable timely initiation of ART among those who test HIV positive, leading to improved life expectancy and lower risks of opportunistic infections (Boyd *et al.*, 2019). At the population level, the expansion of effective ART would reduce HIV transmission, consequently limiting the social and economic burden of the disease (Boyd *et al.*, 2019; Forsythe *et al.*, 2019).

HIV testing and counseling are the first crucial steps for increasing rates of ART use and viral suppression. However, according to the latest UNAIDS estimates, 1.7 million of the 2.1 million know they are HIV positive meaning that 400 thousand (19%) people do not know they are HIV positive in Mozambique (UNAIDS, 2021b). The latest survey by Mozambique`s Ministry of Health (MoH) estimated that 38.7% of women and 60.4% of men ages 15–59 years old living with HIV do not know their HIV status, and the coverage rate of HIV testing in people ages 15–49 years old was only 78% (MISAU and INE 2018).

The government of Mozambique has implemented targeted strategies, including index testing, to improve the identification of PLHIV. Index testing focuses on offering HIV testing services to sexual partners, biological children under 14 years old living in the same household, and parents (in pediatric cases) of a known HIV-infected person. Index testing has been shown to be an efficient strategy to identify and enroll in ART previously undiagnosed individuals in various countries in sub-Saharan Africa, including in Mozambique (Chikwari *et al.*, 2019, 2020; Jubilee *et al.*, 2019; Lasry *et al.*, 2019; Mwango *et al.*, 2020).

Index testing can be done at health facilities or in the community. In Mozambique, facility-based index HIV testing is managed by the MoH, whereas community index testing is managed, due to MoH`s limited funds, by implementing partners such as the Elizabeth Pediatrics AIDS Foundation (EGPAF). Many individuals are reluctant to go to health facilities to do HIV testing for various reasons, with the primary reasons being concern about stigma, discrimination and cost of travelling (Chikwari *et al.*, 2018; Hlongwa *et al.*, 2020). Thus, only a small percentage of the people who need to be tested through facility index testing are actually tested in the health facilities. To improve the yield of index testing, the government decided to implement community index testing through implementing partners. Under this strategy, healthcare workers include HIV testing and counseling in their other routine activities (i.e., health education, vaccination, etc.) in order to protect the privacy of those being tested for HIV.

Expansion of index testing in Mozambique would accelerate the achievement of the first UNAIDS 95 goal, but expanding this approach requires assessing the resource implications of this scale-up. Information on index testing costs and efficiency in Mozambique is scarce. An in-depth cost analysis would help determine the affordability of this strategy and provide policymakers and planners with useful information to better inform how to plan and allocate resources for the expansion of index testing.

In this study, we investigated the costs, cost-efficiency and cost-effectiveness of community HIV index testing in eight districts in Gaza province, Mozambique. Furthermore, we assessed how potential variations in inputs (such as the price of HIV rapid tests) would impact costs and cost-efficiency of index testing in the province.

2. Study objectives

2.1. Primary objective

Calculate the cost-efficiency and cost-effectiveness of a community index testing pilot study in eight districts in Gaza, Mozambique.

2.2. Secondary objectives

- Calculate the total cost of community index testing in eight districts in Gaza.
- Identify the main cost drivers of the community index testing approach.

- Assess the impact of variations in each cost category on the cost per individual tested for HIV and cost per new HIV diagnosis.
- Compare the yield of community index testing and facility-based HIV testing.
- Compare the proportion of male and females tested via community index testing approach versus facility-based testing.

3. Study design and methods

3.1. Community index testing and study location

In collaboration with Aid Development from People for People (ADPP), a local non-governmental organization, EGPAF implemented a pilot community-based HIV counseling and testing based on index cases identified in 102 health facilities (HF) located in eight districts in Gaza province, namely: Bilene (9 HF), Chibuto (16 HF), Chókwè (24 HF), Chongoene (13 HF), Guijá (9 HF), Limpopo (7 HF), Manjakaze (16 HF) and Xai-Xai (8 HF). The Gaza province was chosen for the pilot because it has the highest prevalence of HIV in Mozambique, with 24.4% (MISAU and INE, 2018).

As part of the routine HIV program, the primary index cases were identified from those who tested positive during HF routine HIV testing, care and treatment, and individuals who died of HIV. Primary index cases were extracted from the Open Medical Record System, a database containing demographic and clinical data of patients who used HF services. As part of the pilot, field officers (also known as community lay counselors) then visited all identified HIV individuals, adults and children, in their homes.

Each field officer received a list of index cases to visit in the community and, once family members agreed to be tested, they performed rapid HIV tests and counseling. The target populations were sexual partners of the index case, all biological children under 14 years old living in the same household as the index case, and, in pediatric cases (children under 14 years old), parents of the HIV-infected child. For each index case, there was a tracking form which included information about contacts who belonged to these three high-risk groups was completed.

Index contacts who were known to be HIV positive were not tested or included in the count of testing for the community index case testing. Also, the primary index cases were not included in

the count of community index cases. Furthermore, we did not include the costs of the primary index case test since the testing was done using HF resources and costs were incurred at the HF level. All patients testing positive in the community were referred to the HF for care and treatment as per MoH guidelines.

3.2. Index testing staff and activities

A total of 250 field officers were trained (for HIV testing and counseling) and were responsible for community index testing and counseling in the eight districts included in the study. Supporting personnel involved in the project comprised one project coordinator, one deputy coordinator, one monitoring and evaluation (M&E) officer, eighteen supervisors, seven data entry clerks, one administrative assistant, one cashier, one office assistant, one driver and one accountant.

Based on information from project staff, we estimated that field officers spent 75% of their time on index testing and 25% of their time on tuberculosis (TB) screening and tracing of individuals who were lost to follow-up in the community. For the remaining staff, we sourced estimates of the percentage of their time dedicated to activities related to community index testing from their monthly activities report. Human resources costs were then derived from these percentages and annual salaries (appendix table A1).

As a routine part of the program, the project coordinator made five visits per month to various districts for monitoring and supervision, and the deputy coordinator and M&E officer made ten visits per month to monitor the use of registers and data collection instruments. Project management staff participated in quarterly coordination meetings, and there were two additional meetings per month held in the district capital and attended by supervisors, data entry clerks, the M&E officer, the coordinator and deputy coordinator, and field officers.

3.3. Evaluation of pilot project

The evaluation of the community index testing pilot project was conducted by EGPAF in collaboration with Programa Nacional de Controle de HIV/SIDA (National Control Program for HIV/AIDS) and Direção Provincial de Saúde - Gaza (Gaza's Provincial Health Directorate). These two collaborating organizations also co-authored this report, a manuscript submitted for publication in a peer-reviewed journal (Plos One), and presentations at the national XVII Jornadas

Nacionais de Saúde conference and the 2021 International Conference on AIDS and Sexually Transmitted Infections in Africa (ICASA).

This evaluation did not involve primary data collection; all data were collected from secondary data sources as explained below. The total cost of this evaluation was US$3,739 and consisted mostly of level of effort (LOE) of the staff involved in compiling and analyzing data, as well as writing the report.

3.4. Data collection

Cost data on pilot-related activities in the eight districts were collected from internal financial reports and spreadsheets, databases, and relevant logbooks for a period between October 2017 and September 2018. Costs included human resources, HIV rapid tests, travel and transportation for home visits and supervision, supplies (i.e., stationary, smartphones for field officers, and personal protective equipment), training, and review and coordination meetings (Appendix Table A1). Costs were estimated from a health systems perspective using a micro-costing method, combining top-down and bottom-up approaches to obtain resource use and costs per line item.

Costs were aggregated across districts, because the financial system does not provide disaggregate district financial data. We focused on routine program implementation costs to understand how the community index testing program could be scaled up. All project costs were converted to U.S. dollars ($) using the prevailing exchange rate at the time of purchase or payment from Mozambique`s Central Bank. Since all costs were incurred in the same financial year, we did not adjust 2018 US$. HIV testing services, in the context of community index testing, included the provision of both pre- and post-test counseling, first HIV testing, and confirmatory testing for a positive HIV result.

Trainings were treated as capital costs and annualized over two years, as previously done by Vyas *et al.* (2020). We applied a discount rate of 3% according to WHO guidelines (WHO, 2003) and annualized costs by dividing the total cost of the training by the annuity as described previously (Walker and Kumaranayake, 2002; Kimaro *et al.*, 2017).

We recorded the total number of index cases tested for HIV and the number of index cases who were diagnosed with HIV through the community index testing approach. To obtain the cost per client tested for HIV and new HIV diagnoses, we calculated the total cost of community index

testing in the reporting period and then divided it by the number of clients tested and the number of new HIV diagnoses, respectively. The cost estimation methodology was modelled based on a methodology described by Mwenge *et al.* (2017) and Vyas *et al.* (2020).

3.5. Sensitivity analysis

A one-way sensitivity analysis was performed to assess the impact of variation of each input category on the cost per individual tested for HIV and cost per new HIV diagnosis. The one-way sensitivity analysis consisted of varying each input category by applying a variation range of plus or minus 10% while the others remained the same (Vyas et al. 2020).

3.6. Cost-effectiveness

The transmission rate of HIV-positive individuals who are unaware of their status is 12.1% (average between transmission rate of people acutely infected [16.1%] and people non-acutely infected [8.4%]), HIV-positive individuals who are aware of their status and are on ART but with unsuppressed viral load have a transmission rate of 6.1% whereas those who have viral load suppression are assumed as not transmitting HIV (Li *et al.*, 2019).

Since clients who are diagnosed with HIV initiate ART immediately, we assumed that the HIV transmission rate drops to 6.1% after HIV diagnosis. Thus, we calculated the number of HIV infections averted by multiplying the number of new HIV diagnoses by the difference between HIV transmission rates before and after HIV diagnosis as shown in the formula bellow as described previously (Okoboi *et al.*, 2021):

$$a = Nu\ (Tu – Ta)$$

where: ***a*** is the number of HIV infections averted, ***Nu*** is the number of new HIV diagnoses, ***Tu*** is the average HIV transmission rate of individuals unaware of their status, and ***Ta*** is the HIV transmission rate of individuals aware of their status and are on ART but with unsuppressed viral load.

The cost per infection averted was calculated by dividing the total cost of implementing the pilot community index testing by the number of infections averted.

3.7. Facility-based HIV testing

Facility-based HIV testing includes all HIV tests done at health facilities, such as provider-initiated counseling and testing, testing performed during medical male circumcisions, facility-based index testing and, voluntary counseling and testing (PEPFAR 2020).

The number of clients tested for HIV and the number of new HIV diagnoses between October 2017 and September 2020 in 102 health facilities were extracted from Open Medical Records Systems from the eight districts included in the pilot. The reason the indicators data is from October 2017 to September 2020, unlike for cost data, which is from October 2017 to September 2018, was to assess the overall trend in testing and outcomes in the districts included in the study.

3.8. Data management

Project data collection: The field officers submitted logbooks containing completed data collection forms to their respective supervisors, who kept the documents in lockable cabinets at the health facilities. Data was entered into District Health Information Software by data clerks and validated by an M&E officer as per approved guidelines. For this study, only aggregated data was used.

Project data control: A data quality assessment was done by M&E officer by comparing the data in the primary source (logbooks) and the aggregated data entered into the District Health Information Software. Data discrepancies were analyzed using a data quality assessment tool.

3.9. Quality control

The supervisors communicated directly with the project management team to report any challenges in data collection. Data deficiencies were identified and corrected, and the responsible field officer was informed.

3.10. Data backup

Data were entered into a password-protected database. A restricted shared folder was created on the local server, which is backed-up daily.

4. Limitations

The current study did not disaggregate cost data by district, nor did it include capital costs (although those were anticipated to be minor). We also did not compile costs for facility-based testing in Gaza, but rather used published benchmarks to compare the costs of index testing versus facility-based testing.

5. Ethical considerations

This evaluation was implemented by EGPAF staff under the auspices of EGPAF's Patient and Program Outcomes Protocol. Permission and ethical clearance to conduct this study was obtained from the local institutional review board (IRB) (approval number CNBS/656/19) and Advarra in the United States.

This protocol is limited to the analysis of secondary data that were routinely collected as part of the standard services. This evaluation did not involve direct interaction with participants. No additional patient information was collected outside of the records at the time of data extraction.

6. Confidentiality

EGPAF adheres to national program guidelines concerning the maintenance of confidentiality of patient medical records, using identifiers only when required to provide medical care or supportive services. In addition, all EGPAF employees signed a data handling and confidentiality agreement, and EGPAF staff involved with accessing or analyzing data for this study completed an online research ethics course on human subject protection in research. All EGPAF computers are password protected and only aggregated data was used. Analytical datasets were not shared with anyone outside of EGPAF, CDC, or the Mozambique Ministry of Health (MOH).

7. Results

7.1. HIV testing service delivery and costs

A total of 91,441 individuals were tested for HIV through community index testing, of which 7,011 tested HIV-positive (7.7% of new HIV diagnoses). Human resources were the major cost driver (52%), followed by the purchase of HIV rapid tests (28%), supplies (8%), training (6%), communication and review meetings (3%), travel for supervision and home visits (3%) (table 1 and appendix tables A2a–d). The cost per individual tested was US$5.82, and the cost per new HIV diagnosis was US$65.32 (table 2).

Table 1. Total annual community index testing and counseling costs

Category	Amount ($)	Percentage (%)
Human resources	299,245	52
Travel and transportation	14,215	3
Annualized training costs	34,820	6
Supplies	43,108	8
Communication and review meetings	18,680	3
Subtotal excluding HIV rapid test costs	410,068	72
Screening for HIV with Determine HIV rapid Test	122,522	21
Confirmation of HIV with Uni-Gold HIV rapid Test	38,522	7
Subtotal HIV rapid tests	161,044	28
Total	**571,112**	**100**

Table 2. Cost per client tested for HIV and cost per new HIV diagnosis

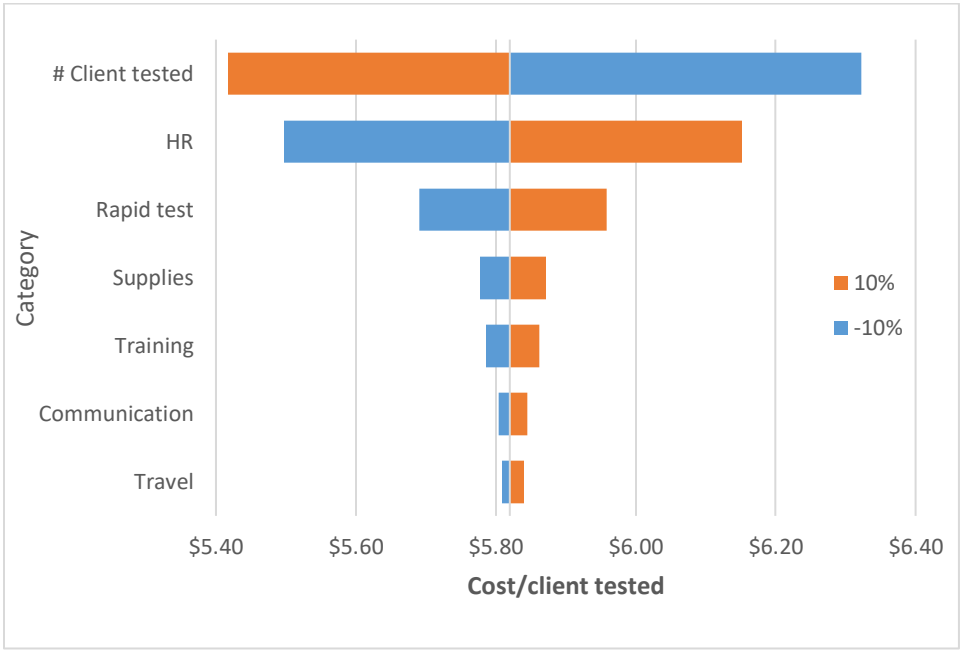
Category		Value
Costs	Total annual costs excluding HIV rapid tests	$410,068
Number of clients	Clients tested	91,441
	New HIV diagnoses	7,011
Cost per client excluding the cost of rapid tests	Cost per client tested for HIV	$4.48
	Cost per new HIV diagnosis	$58.49
Price per HIV rapid test	Screening for HIV with Determine HIV rapid test	$1.34
	Confirmation of HIV diagnosis with Uni-Gold HIV rapid test	$5.49
Total cost per client	**Cost per client tested***	**$5.82**
	Cost per new HIV diagnosis**	**$65.32**

*Includes only cost of Determine HIV rapid test.
**Includes cost of Determine and Uni-Gold HIV rapid tests.

There are no publicly available estimates of cost per client tested and per new HIV diagnosis in health facilities in Mozambique. However, Mwenge *et. al.* (2017) estimated these costs (in 2016 $) for facility-based testing in Malawi, Zambia, and Zimbabwe (Mwenge *et al.*, 2017). These estimates were used for our analysis after adjusting to 2018 $ using U.S. consumer price index (Appendix Table A4). The estimated the mean cost per client tested was $5.15 in Malawi, $4.44 in Zambia, and $9.20 in Zimbabwe. The mean cost per new HIV diagnosis was $83.26 in Malawi, $77.04 in Zambia, and $187.19 in Zimbabwe.

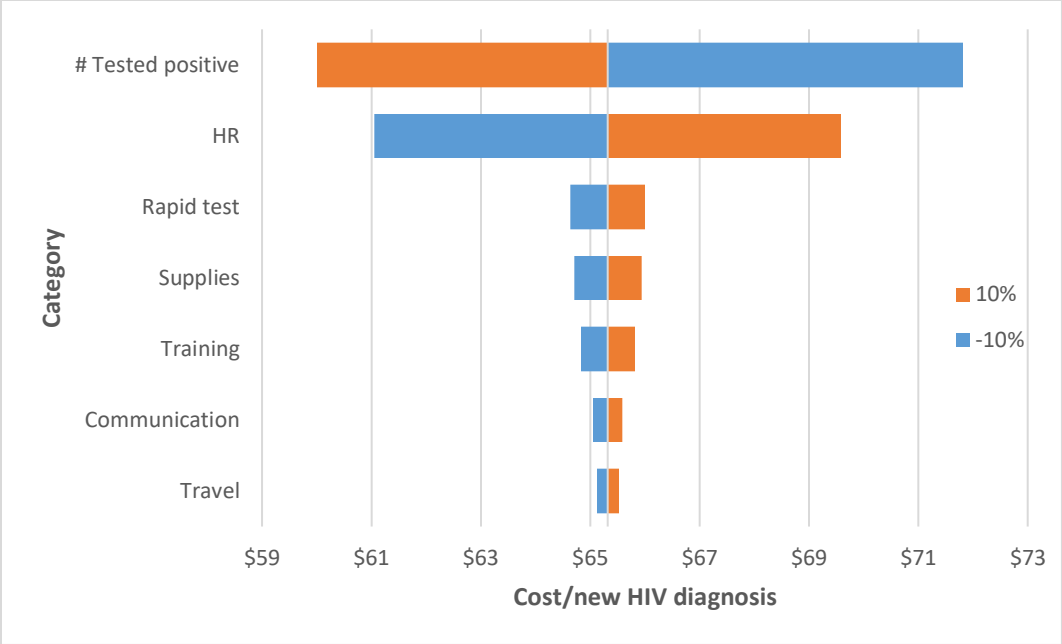
7.2. Sensitivity analysis

When inputs were varied by plus (orange) or minus (blue) 10%, only human resources, number of clients tested (and new HIV diagnoses), and purchase of HIV rapid tests caused considerable variation in both cost per client tested and cost per new HIV diagnosis. The biggest impact was caused by varying plus or minus 10% in the number of clients tested (and new HIV diagnoses), which had an inverse correlation (figures 1a and 1b and appendix tables A3a and A3b).



Note: Two values for each input category were used (±10%), the lowest in the range (blue) and highest in the range (orange), while the rest of the parameters remained the same.

Figure 1a. Tornado plot of one-way sensitivity analysis: cost per client tested.



Note: Two values for each input category were used (±10%), the lowest in the range (blue) and highest in the range (orange), while the rest of the parameters remained the same.

Figure 1b. Tornado plot of one-way sensitivity analysis: cost per new HIV diagnosis.

7.3. Cost-effectiveness

We first calculated the number of infections averted (***a*)** through multiplying the total number of new HIV diagnoses by the difference between transmission rate before (12.1%) and after (6.1%) HIV diagnosis:

a = 7,011 * (0.121 – 0.061) = 421

Next, the total cost of community index testing was divided by the number of infections averted calculated above to calculate the cost per infection averted:

Cost per infection averted = $571,112/421 = $1,358

The estimated cost per HIV infection averted of the pilot community index testing in Gaza was $1,358.

7.4. Number of clients tested and new HIV diagnoses through facility-based and community index testing

A total of 260,659 HIV tests were performed at the 102 HF in the eight districts included from October 2017 to September 2018, with 10,673 new HIV diagnoses (4.1%) (Table 3). Worryingly, the number of clients tested declined from 473,947 in September 2019 to 306,987 by September

2020, and the number of new HIV diagnoses declined from 16,548 to 12,329 in the same period. In comparison, for community index testing, the total number of patients tested declined from 91,441 in September 2018 to 19,542 in September 2020 and the number of new HIV diagnoses declined from 7,011 to 2,728 in the same period; however, the percentage of new HIV diagnoses increased from 7.7% to 14.0%.

Table 3. Number of clients tested for HIV, number of new HIV diagnoses, and percentage of new HIV diagnoses through HF and community index testing.

Period	Gender	Clients tested				New HIV diagnoses				% new HIV diagnoses	
		# of clients tested		Percentage (%)		# of new HIV diagnoses		Percentage (%)			
		FT*	CIT**	FT	CIT	FT	CIT	FT	CIT	FT	CIT
October 2017-September 2018	Total	260,659	91,441	100	100	10,673	7,011	100	100	4.1	7.7
	Female	189,434	43,390	73	47	6,743	3,751	63	54	3.6	8.6
	Male	71,225	48,051	27	53	3,930	3,260	37	46	5.5	6.8
October 2018-September 2019	Total	473,947	46,190	100	100	16,548	3,655	100	100	3.5	7.9
	Female	354,102	24,157	75	52	10,767	1,970	65	54	3.0	8.2
	Male	119,845	22,033	25	48	5,781	1,685	35	46	4.8	7.6
October 2019-September 2020	Total	306,987	19,542	100	100	12,329	2,728	100	100	4.0	14.0
	Female	238,191	10,593	78	54	8,049	1,466	65	54	3.4	13.8
	Male	68,796	8,949	22	46	4,280	1,262	35	46	6.2	14.1

*FT - HF testing.
**CIT – Community index testing.

Overall, in the last three years, community index testing had higher percentage of new HIV diagnoses and a higher percentage of men screened and diagnosed with HIV. The percentage of male individuals tested through community index testing varied between 46%–53% whereas through facility-based testing this percentage varied between 22%-27%. A similar trend was observed for the number of new HIV diagnoses, 46% in community index testing vs 35-37% in facility-based testing, indicating that community index testing reaches proportionally more men.

8. Discussion

This is first study conducted in Mozambique that estimated the cost per client tested, new HIV diagnosis and per HIV infection averted for community index testing; it also highlighted that this testing strategy reaches proportionally more men than facility-based testing. From October 2017 to September 2020, men testing through community index testing was between 9-38% of all men tested and men identified as new HIV diagnoses in community index testing was 22-32% of all men identified as new HIV diagnoses, indicating a considerable contribution of community index testing (Appendix Table A5).

According to the latest UNAIDS report (2021), globally, men continue to fare worse than women in terms of HIV testing, with one million more men than women living with an undiagnosed HIV infection. Our findings that community index testing reaches proportionally more men and has better percentage of new HIV diagnoses than facility-based testing, at a cost per new HIV diagnosis that is lower than published facility-based benchmarks in three countries in Southern Africa (Malawi, Zambia and Zimbabwe) (Appendix Table A4) (Mwenge et al. 2017), suggests that community index testing may be an effective and efficient strategy to increase identification of previously undiagnosed men.

The costs per client tested and per new HIV diagnosis in HF in Malawi, Zambia and Zimbabwe were also sensitive to variations in the number of clients tested (and number of new HIV diagnoses), human resources, and costs of HIV rapid tests (Mwenge *et al.*, 2017). Because the cost per new HIV diagnosis - in both our study and Mwenge *et al.* (2017) - is affected by the number of new HIV diagnoses, personnel, and costs of HIV test kits, the lower estimated cost reported here may be affected by differences in these parameters between locations.

A systematic review and meta-analysis of community index testing in sub-Saharan Africa by Sharma *et al.* (2015) estimated an average cost per person tested of $16.60 in 2012 ($18.16 in 2018), which is much higher than our estimate ($5.82). Our study does not include capital costs, but the pilot community index testing utilized minimal capital resources in its implementation, and therefore, capital or overhead costs are unlikely to have a substantial impact on these results. Thus, our estimated costs per client tested and per new HIV diagnosis would remain lower than those reported for facility-based (Mwenge et al. 2017) and index testing (Sharma et al. 2015), even if we considered capital costs.

An earlier study identified a strong relationship between cost per new HIV diagnosis and cost effectiveness for testing programs in low-income settings in southern Africa (Phillips et al. 2019). This strong relationship reported in Phillips *et al.* further supports our finding that community index testing in Gaza is cost-effective. To our knowledge, there are no peer-reviewed published estimates of cost per infection averted for community index testing in sub-Saharan Africa. However, Okoboi *et al.* (2021) estimated in Uganda that the cost-effectiveness of peer distributed HIV oral fluid self-test kits (a type of community HIV testing) in men who have sex with men sexual and their social networks was $6,253 per infection averted whereas for standard-of-care hotspot testing was $17,567. Both of these estimates are much higher than $1,358 per infection averted estimated in the current study. The difference in the cost per infection averted between our study and Okoboi *et al.* (2021) may be due to differences in the number of clients tested and new HIV diagnosis, salaries and price of HIV rapid tests which, as shown in this study, are major cost drivers.

This study identifies the main cost drivers for index testing in Mozambique, and the data generated here can be used to improve planning, budgeting, and resource allocation. Improved management of HIV testing is urgently needed, since external donor spending on HIV/AIDS in Africa has been declining significantly over the last few years; in 2015 alone, it declined by more than US$1 billion (Haakenstad et al. 2019; Kates, Wexler, and Lief 2016;). African countries have been forced to increase their domestic budgets to fight the HIV/AIDS pandemic but face a wide range of constraints, including limited financial and human resources and debilitated infrastructure (Haakenstad et al. 2019). In addition, the COVID-19 pandemic caused major disruptions to healthcare systems, leading to supply shortages and diversion of human and financial resources (Hogan et al. 2020).

Due to COVID-19 pandemic, there was a pronounced decrease in the overall number of people tested and new HIV diagnoses between October 2019 and September 2020. The pandemic forced temporary closure of facilities, staff shortages (due to contracting disease or undertaking COVID-19 related activities at the health facility), and individuals being afraid to visit the health facilities due to fear of exposure to the virus (Mhango, Chitungo, and Dzinamarira 2020).

As the output and yield of facility-based testing decline (table 3), and with the introduction of new testing modalities in Mozambique—most notably self-testing, which is in the early stages of rollout—it is important to understand the costs of resources required to implement testing strategies such as community index testing that complement facility-based testing. This analysis may help to increase that understanding.

9. Conclusion

Our data suggest that the expansion of index testing would accelerate achieving the goal of identifying 95% of the people living with HIV by 2030 and would offer value for the investment. In addition, the current data suggest that community index testing may be an efficient strategy to increase identification of previously undiagnosed men. These findings show that analyses of program inputs are a useful tool to identify main cost drivers, inform planning, and improve efficiency and resource allocation in an era of declining funding.

10. Recommendations

Based on sensitivity analysis, when budgeting for expansion of the index testing strategy, particular attention should be paid to the size of the target population, purchase of HIV rapid tests, and personnel salaries, as these factors have the largest impact on the cost per individual tested and per new HIV diagnosis. In addition, community index testing should be implemented as a complementary approach to existing testing methods to reach more undiagnosed men.

11. Research utilization

Findings will be used first and foremost to provide input on program implementation costs and efficiency and to provide data to improve budgeting and planning. Findings may also be used to describe programmatic approaches and to inform Mozambique's governmental policy on delivering HIV testing at facilities or through index testing.

12. Dissemination

As applicable, evaluation reports on key questions analyzed will be shared with appropriate stakeholders, including CDC and MOH, as well as global EGPAF staff and other implementing partners. A final evaluation report will be produced in alignment with PEPFAR Evaluation Standards of Practice requirements and posted on a publicly accessible website within 90 days of clearance.

The authors gave an oral presentation of the findings of this report at Mozambique's XVII Jornadas Nacionais de Saúde conference, which took place in Maputo from September 8–10, 2021. The findings were also presented in poster format at ICASA in Durban, South Africa, from December 6–11, 2021. Furthermore, the results of this study were presented and discussed with Gaza`s Provincial Health Directorate on March 17, 2022. In addition, the authors submitted a manuscript for publication in Plos One, a peer-reviewed journal.

13. Competing interests

The authors declare no competing interests.

14. Evaluation team

Authors` roles

ARC, SM, NB, SSM designed the study; CCM, AC, ND, CM, AM were involved in data curation; MS, SSM performed data analysis with input from NB, CCM. AM, SM, AN, RN, AC and CM supervised and advised on the overall conduct of the study; MS, NB and SSM drafted the manuscript. All authors have read and agreed to the published version of the manuscript.

Authors` background and qualifications

Mario Songane (MS) – has Master of Research in Biomedicine, PhD in Innate Immunity and Infection, and a Master in Business Administration. Highly versatile professional who has worked in various healthcare fields (Biomedical Research, Health Policy, Health Economics, Therapy

Evaluation and Monitoring) in different countries (Mozambique, United Kingdom, The Netherlands, Canada and Switzerland). Has various publications in the field of Health Economics and Policy. Currently is the Regional Advisor for Economic Evaluations at EGPAF.

Celia Magaia (CCM) - has a bachelor in Accounting Science with specialization in auditing. Celia is an experienced accountant with more than 8 years in financing management. At EGPAF, she is the Finance Senior Manager responsible for managing accounts, financial systems and administrative procedures to ensure compliance with donor requirements. Celia is also responsible for advising the Senior Management Team on matters related to budgets, contracts, procurement regulations and donor policies.

Aleny Couto (AC) – Is a Medical Doctor. She is the Head of STI and HIV/AIDS program at MoH. Dr. Couto has experience in the management and implementation of national and provincial level health programs with a specific focus on HIV/AIDS, as well designing policies, country guidelines, and strategic plans following WHO guidelines. Dr. Couto has participated in the expansion of an HIV scale up plan and also implemented a wide range of Public Health Programs.

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Atanasio Mabote (AM) – has a degree in Sociology. Currently is the Advisor for Community Engagement at EGPAF. Is responsible for technical assistance to the province and district teams following the health counseling and testing activities based on the index cases. Has solid skills in social projects, working on programmatic components in international NGOs since September 1995, and in the last 10 years in programs related to HIV/AIDS.

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Amancio Nhangave (AN) – has a degree in Radiology and currently is enrolled in a Master in Public Health program at University Eduardo Mondlane. Currently is the Focal Point for Research at Gaza Provincial Health Directorate where he is involved in multiple HIV related projects with EGPAF in various areas such as HIV counseling and testing at facility and community levels, pharmacovigilance, clinical and qualitative studies.

Nilesh Bhatt (NB) – is a Medical Doctor with a Master in Medicine (STD-HIV/AIDS) and PhD in Infectious Diseases. Currently is the Global Director for Clinical Research at EGPAF (Washington, USA) and at the time of the study was the Mozambique`s Research Director. Prior to joining EGPAF was the Director of the Centro de Investigacao e Treino em Saude da Polana Canico and a Senior Research at Instituto Nacional de Saude. Nilesh has published over 20 peer-reviewed articles, most of them on HIV/AIDS and TB.

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16. Appendix

Table A1. Cost data collection tool

PERSONNEL & ALLOWANCES						
Cadre	**Unit**	**# of months**	**Monthly salary**	**Level of effort (%)**	**# employees**	**Total cost**
Project coordinator	*Month*					
Deputy coordinator	*Month*					
M&E officer	*Month*					
Supervisors	*Month*					
Data Entry	*Month*					
Field officers	*Month*					
Administrative assistant	*Month*					
Cashier	*Month*					
Servant	*Month*					
Driver	*Month*					
Accountant	*Month*					
TRAVEL						
Trip Description	**Frequency**	**# of trips**	**Fuel**	**Accommodations**	**Per diem**	**Total cost**
Quarterly coordination meeting						
Coordinator—monitoring and supervision 5 days/month						
Monitoring of the use of registration and data collection instruments by the M&E team and deputy coordinator						
Twice per month—meeting with field officers in district capital						
SUPPLIES						
Item	**Units**	**# units**	**Unit price**	**Total cost**		
Gloves (50 pairs)						
Cotton wool (500 g)						
Toilet paper						
Glycerinated gel flask 80–100 ml						
Cotton (pack of 200)						
Face masks						
Copies of invoices						
Copies of family trees, diary of community health counseling and testing						

Preprinted forms for monitoring and follow-up of all index cases				
Register book for activists (100 pages each)				
Office supplies				
Maintenance of cars				
Maintenance of motorbikes				
Maintenance of bicycles				
Laptop for coordinator and administrator				
TRAINING				
Participants and length				
Category	**Number**			
Length of training (days)				
Participants				
Costs				
Category	**Unit costs (US$)**	**Total costs (US$)**		
Venue rent				
Lunch				
Per diem				
Accommodations				

Table A2a. Breakdown of total costs of testing and counseling

Cost Category	Total Cost	% of total cost
Human resources	$299,245	52.40
Supervisors	$25,664	4.49
Data entry clerks and M&E	$18,480	3.24
Field officers	$231,998	40.62
Support staff	$10,508	1.84
Total fringe	$12,595	2.21
Travel and Transportation	$14,215	2.49
Supervision	$10,324	1.81
Transportation for field officers	$3,892	0.68
Annualized training costs*	$34,820	6.10
Testing and counseling training for field officers (Table S1b)	$41,349	
CommCare training for field officers (Table S1c)	$24,809	
Supplies	$43,108	7.55
Gloves	$4,254	0.74
Cotton wool (500 g)	$3,093	0.54
Toilet paper	$937	0.16
Glycerinated gel flask 80–100 ml	$3,239	0.57
Cotton wool (500 g)	$1,979	0.35
Face masks	$3,369	0.59
Copies of invoices	$1,135	0.20
Copies of family trees, diary of community health counseling and testing	$1,751	0.31
Preprinted forms for monitoring and follow-up of all index cases	$812	0.14
Register book for activists (100 pages each)	$1,053	0.18
Depreciation in one year of smart phones purchased for field officers (Table S1d)	$21,485	3.76
Communication and Review Meetings	$18,680	3.27
Airtime and communication for field officers	$5,621	0.98
Review meetings with field officers (district capital)	$10,813	1.89
Review meetings with supervisors, M&E, and data entry staff	$2,246	0.39
Subtotal—excluding HIV rapid tests	$410,068	71.80
Screening for HIV with Determine HIV rapid test	$122,522	21.45
Confirmation of HIV with Uni-Gold HIV rapid test	$38,522	6.75
Subtotal—HIV testing	$161,044	28.20
Total	**$571,112**	**100.00**

*****Total training costs were annualized over 2 years (Vyas *et al.*, 2020), at a discount rate of 3% as recommended by WHO (WHO, 2003) and using an annuity of 1.9, similar to (Walker and Kumaranayake, 2002).

Table A2b. Cost of testing and counseling training for field officers.

Category	Item	#	Unit cost (MZN)	Total cost (MZN)
Duration	Number of days	5		
Venue	Venue rent for 5 days	1	5,000	25,000
Lunch	Lunch for 5 days and 32 participants	32	450	72,000
Per diem	Per diem (400 MZN) for 30 field officers for 5 days	30	400	60,000
	EGPAF facilitator (per diem + accommodations)	1	6,350	31,750
	MOH facilitator (per diem + accommodations)	1	6,000	30,000
	Subtotal—per diem			218,750
	Total cost per training week			315,750
	Took 8 groups of 30 participants to train 250 field officers (250/30)	8	315,750	2,526,000
	Exchange rate (Oct. 2017)			61.09
	Total cost ($)			**$41,349**

Table A2c. Cost of commcare database training for field officers.

Category	Item	#	Unit cost (MZN)	Total cost (MZN)
Duration	Number of days	3		
Venue	Venue rent for 3 days	1	5,000	15,000
Lunch	Lunch for 3 days and 32 participants	32	450	43,200
Per diem	Per diem (400 MZN) for 30 field officers for 3 days	30	400	36,000
	EGPAF facilitator (per diem + accommodations)	1	6,350	19,050
	MOH facilitator (per diem + accommodations)	1	6,000	18,000
	Subtotal—per diem			131,250
	Total cost per training week			189,450
	Took 8 groups of 30 participants to train 250 Field Officer (250/30)	8	189,450	1,515,600
	Exchange rate (Oct. 2017)			61.09
	Total cost ($)			**$24,809**

Table A2d. Table S1d. Cost of depreciation of smartphones purchased for field officers.

Category	Value
Number of field officers	250
Cost per smart phone	MZN15,000
Total cost	MZN3,750,000
Exchange rate (Oct 2017)	MZN61.09
Total cost ($)	**$61,384.84**
First year depreciation (35%) ($)[+]	**$21,484.69**

[+]According to Makov et al. (Makov *et al.*, 2019), Samsung smartphones lose 35% of their value in the first year.

Table A3a. One-way sensitivity analysis of input categories (human resources, travel and transportation, supplies, and communication and review meetings) on cost per client tested and cost per new positive diagnosis.

	Category		Human resources		Travel and Transportation		Supplies		Communication and Review Meetings	
		Value	+10%	-10%	+10%	-10%	+10%	-10%	+10%	-10%
Costs	Human resources	$299,245	$329,169	$269,320	$299,245	$299,245	$299,245	$299,245	$299,245	$299,245
	Travel and transportation	$14,215	$14,215	$14,215	$15,637	$12,794	$14,215	$14,215	$14,215	$14,215
	Supplies	$43,108	$43,108	$43,108	$43,108	$43,108	$47,419	$38,797	$43,108	$43,108
	Communication and review meetings	$18,680	$18,680	$18,680	$18,680	$18,680	$18,680	$18,680	$20,548	$16,812
	Annualized training costs	$34,820	$34,820	$34,820	$34,820	$34,820	$34,820	$34,820	$34,820	$34,820
	Subtotal—without HIV rapid tests	$410,068	$439,993	$380,144	$411,490	$408,647	$414,379	$405,757	$411,936	$408,200
	Screening—Determine HIV rapid test	$122,522	$122,522	$122,522	$122,522	$122,522	$122,522	$122,522	$122,522	$122,522
	Confirmation—Uni-Gold HIV rapid test	$38,522	$38,522	$38,522	$38,522	$38,522	$38,522	$38,522	$38,522	$38,522
	Subtotal—HIV rapid tests	$161,044	$161,044	$161,044	$161,044	$161,044	$161,044	$161,044	$161,044	$161,044
	Total	$571,112	$601,036	$541,187	$572,533	$569,690	$575,423	$566,801	$572,980	$569,244
Number of clients	Clients tested	91,441	91,441	91,441	91,441	91,441	91,441	91,441	91,441	91,441
	New HIV diagnoses	7,011	7,011	7,011	7,011	7,011	7,011	7,011	7,011	7,011
Cost per client excluding HIV rapid test	Cost per client tested	$4.48	$4.81	$4.16	$4.50	$4.47	$4.53	$4.44	$4.50	$4.46
	Cost per new HIV diagnosis	$58.49	$62.76	$54.22	$58.69	$58.29	$59.10	$57.87	$58.76	$58.22
Price per HIV rapid test	Screening—Determine HIV rapid test	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34
	Confirmation—Uni-Gold HIV rapid test	$5.49	$5.49	$5.49	$5.49	$5.49	$5.49	$5.49	$5.49	$5.49
Cost per subjects with HIV rapid test	Cost per client tested	$5.82	$6.15	$5.50	$5.84	$5.81	$5.87	$5.78	$5.84	$5.80
	Cost per new HIV diagnosis	$65.32	$69.59	$61.06	$65.53	$65.12	$65.94	$64.71	$65.59	$65.06
	% Variation of cost/client tested		**5.62**	**-5.62**	**0.27**	**-0.27**	**0.81**	**-0.81**	**0.35**	**-0.35**
	% Variation of cost/new HIV diagnosis		**6.53**	**-6.53**	**0.31**	**-0.31**	**0.94**	**-0.94**	**0.41**	**-0.41**

Table A3b. One-way sensitivity analysis of input categories (training, number of clients tested, number of clients tested positive, and price of rapid tests) on cost per client tested and cost per new positive diagnosis.

	Category		Training		# clients tested		# new HIV diagnoses		Price of HIV rapid test	
		Value	+10%	-10%	+10%	-10%	+10%	-10%	+10%	-10%
Costs	Human resources	$299,245	$299,245	$299,245	$299,245	$299,245	$299,245	$299,245	$299,245	$299,245
	Travel and transportation	$14,215	$14,215	$14,215	$14,215	$14,215	$14,215	$14,215	$14,215	$14,215
	Supplies	$43,108	$43,108	$43,108	$43,108	$43,108	$43,108	$43,108	$43,108	$43,108
	Communication and review meetings	$18,680	$18,680	$18,680	$18,680	$18,680	$18,680	$18,680	$18,680	$18,680
	Annualized training costs	$34,820	$38,302	$31,338	$34,820	$34,820	$34,820	$34,820	$34,820	$34,820
	Subtotal—without HIV rapid tests	$410,068	$413,550	$406,586	$410,068	$410,068	$410,068	$410,068	$410,068	$410,068
	Screening—Determine HIV rapid test	$122,522	$122,522	$122,522	$122,522	$122,522	$122,522	$122,522	$122,522	$122,522
	Confirmation—Uni-Gold HIV rapid test	$38,522	$38,522	$38,522	$38,522	$38,522	$38,522	$38,522	$38,522	$38,522
	Subtotal—HIV rapid tests	$161,044	$161,044	$161,044	$161,044	$161,044	$161,044	$161,044	$161,044	$161,044
	Total	$571,112	$574,594	$567,630	$571,112	$571,112	$571,112	$571,112	$571,112	$571,112
Number of clients	Clients tested	91,441	91,441	91,441	100,585	82,297	91,441	91,441	91,441	91,441
	New HIV diagnoses	7,011	7,011	7,011	7,011	7,011	7,712	6,310	7,011	7,011
Cost per client excluding HIV rapid test	Cost per client tested	$4.48	$4.52	$4.45	$4.08	$4.98	$4.48	$4.48	$4.48	$4.48
	Cost per new HIV diagnosis	$58.49	$58.99	$57.99	$58.49	$58.49	$53.17	$64.99	$58.49	$58.49
Price per HIV rapid test	Screening—Determine HIV rapid test	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.47	$1.21
	Confirmation—Uni-Gold HIV rapid test	$5.49	$5.49	$5.49	$5.49	$5.49	$5.49	$5.49	$6.04	$4.95
Cost per subjects with HIV rapid test	Cost per client tested	$5.82	$5.86	$5.79	$5.42	$6.32	$5.82	$5.82	$5.96	$5.69
	Cost per new HIV diagnosis	$65.32	$65.82	$64.83	$65.32	$65.32	$60.01	$71.82	$66.01	$64.64
	% Variation of cost/client tested		**0.65**	**-0.65**	**-7.00**	**8.56**	**0.00**	**0.00**	**2.30**	**-2.30**
	% Variation of cost/new HIV diagnosis		**0.76**	**-0.76**	**0.00**	**0.00**	**-8.14**	**9.95**	**1.05**	**-1.05**

Table A4. Cost per individual tested for HIV and cost per new HIV diagnosis in Malawi, Zambia and Zimbabwe

2016 US$						2018 US$					
Cost per client tested			Cost per client tested +			Cost per client tested			Cost per client tested +		
Malawi	Zambia	Zimbabwe	Malawi	Zambia	Zimbabwe	Malawi	Zambia	Zimbabwe	Malawi	Zambia	Zimbabwe
4.92	4.24	8.79	79.58	73.63	178.92	5.15	4.44	9.20	83.26	77.04	187.19

Source: Mwenge et al. (2017) for 2016 data. The costs were converted to 2018 using the US Consumer Price Index.

Table A5. Number of clients tested and new HIV diagnoses through community index and facility-based testing as percentage of total number of clients tested and new HIV diagnoses.

Period		# of clients tested					# of new HIV diagnoses				
	Gender	Total	CIT	CIT as % of Total	FT	FT as % of Total	Total	CIT	CIT as % of Total	FT	FT as % of Total
October 2017-September 2018	Total	491,660	91,441	19	260,659	53	29,022	7,011	24	10,673	37
	Female	365,776	43,390	12	189,434	52	18,868	3,751	20	6,743	36
	Male	125,884	48,051	38	71,225	57	10,154	3,260	32	3,930	39
October 2018-September 2019	Total	604,144	46,190	8	473,947	78	20,618	3,655	18	16,548	80
	Female	435,482	24,157	6	354,102	81	13,102	1,970	15	10,767	82
	Male	168,662	22,033	13	119,845	71	7,516	1,685	22	5,781	77
October 2019-September 2020	Total	390,327	19,542	5	306,987	79	14,056	2,728	19	12,329	88
	Female	292,950	10,593	4	238,191	81	9,049	1,466	16	8,049	89
	Male	97,377	8,949	9	68,796	71	5,007	1,262	25	4,280	85