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Can a conditional financial incentive (CFI) reduce socio-demographic inequalities in home-based HIV testing uptake? A secondary analysis of the HITS clinical trial intervention in rural South Africa

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ABSTRACT

In sub-Saharan Africa, home-based HIV testing interventions are designed to reach sub-populations with low access to HIV testing such as men, younger or less educated people. Combining these interventions with conditional financial incentives (CFI) has been shown to be effective to increase testing uptake. CFI are effective for one-off health behaviour change but whether they operate differentially on different socio-demographic groups is less clear. Using data from the HITS trial in South Africa, we investigated whether a CFI was able to reduce existing home-based HIV testing uptake inequalities observed by socio-demographic groups. Residents aged ≥15 years in the study area were assigned to an intervention arm (16 clusters) or a control arm (29 clusters). In the intervention arm, individuals received a food voucher (~3.5 US dollars) if they accepted to take a home-based HIV test. Testing uptake differences were considered for socio-demographic (sex, age, education, employment status, marital status, household asset index) and geographical (urban/rural living area, distance from clinic) characteristics. Among the 37,028 residents, 24,793 (9290 men, 15,503 women) were included in the analysis. CFI increased significantly testing uptake among men (39.2% vs 25.2%, $p < 0.001$) and women (45.9% vs 32.0%, $p < 0.001$) with similar absolute increase between men and women. Uptake was higher amongst the youngest or least educated individuals, and amongst single (vs in union) or unemployed men. Absolute uptake increase was also significantly higher amongst these groups resulting in increasing socio-demographic differentials for home-based HIV testing uptake. However, because these groups are known to have less access to other public HIV testing services, CFI could reduce inequalities for HIV testing access in our specific context. Although CFI

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significantly home-based HIV testing uptake, it did not do so differentially by socio-demographic group. Future interventions using CFI should make sure that the intervention alone does not increase existing health inequities.

1. Background

Changing individual health behaviours is notoriously difficult but conditional financial incentives (CFI) show considerable promise (Giles et al., 2014; Adams et al., 2014). CFI operate by offering an immediate reward when the future benefit of adopting a health behaviour is perceived as uncertain (Giles et al., 2014). They are particularly effective in promoting one-off behaviours such as adult vaccination and screening (Stone et al., 2002), although their use can be interpreted as coercion or even deemed as inappropriate and wasteful (McNaughton et al., 2016). With regard to HIV-related behaviours, CFI have been shown to be effective for several behaviours including testing, adherence to antiretroviral treatment (ART) and continuity in care (Krishnamoorthy et al., 2021). They lead to higher HIV-testing uptake among men and women (Kim et al., 2017; Kranzer et al., 2018; Thornton, 2008; Elul et al., 2017; Tanser et al., 2021) and linkage to ART for those HIV-positive (Elul et al., 2017; McNairy et al., 2017) although their effect on longer term viral suppression remains unproven (McNairy et al., 2017; Thirumurthy et al., 2019; Yotebieng et al., 2016).

CFI focuses on psychological leverage of an immediate reward when the future benefit of adopting a health behaviour is perceived as uncertain (Giles et al., 2014). Individuals are not perfect rational choice makers and can be present-biased (i.e. favouring immediate rewards) and value more immediate or short-term consequences rather than those in the distant future with greater benefits (Frederick et al., 2002). Although the effect of CFI on one-off health behaviours is clear, whether they operate differently in different socio-economic groups and thus their potential to reduce health inequalities is suggested but not demonstrated (Haff et al., 2015; Oliver and Brown, 2012). On the other hand, while present biasedness remains the main mechanism leveraged by CFI, evidence show that the level of present biasedness can vary between age, gender, socio-economic situation or marital status (Hunter et al., 2018). Thus, offering a CFI for the adoption of a health behaviour may lead to different level of adoption by sociodemographic subgroups. Understanding the differential effect of CFI on health behaviour adoption is important to ensure that it does not create or increase existing inequalities for that behaviour.

Most studies on CFI demonstrate the overall effect of CFI rather than its effect on sub-groups (Oliver and Brown, 2012) and participant-level data, required to conduct a robust analysis of effect on sub-groups, are not commonly published (Zarin, 2013). In the US and UK, the few studies that were conducted found no difference in CFI effect by gender, age, race, income or education (Haff et al., 2015; Mantzari et al., 2015). Another US study, conducted in a healthcare management company, showed a higher effect of a lottery-based CFI among people with a lower income (Haisley et al., 2012). In low and middle-income countries, we found a single survey documenting the link between socio-demographic characteristics and CFI effect for a health intervention, which was attending an HIV result centre after accepting a free door-to-door HIV test in rural Malawi (Thornton, 2008). This study showed various effects of the CFI on gender depending on the study district considered; the author suggested that a woman may be less likely to obtain their test results as she might need to ask her husband permission first in some of the studied sites.

In relation to HIV-testing, there are clear inequalities in access and uptake (Ante-Testard et al., 2020). In South Africa, the country hardest hit by the HIV-epidemic (UNAIDS data 2021, 2021), HIV testing access remain lower among men, young, single, unemployed or less educated people (National Department of Health [South Africa], 2019; Venkatesh et al., 2011). Interventions such as home-based HIV testing are designed to increase HIV testing uptake among these sub-groups (Baisley et al., 2019). While home-based HIV testing is shown to increase uptake among unemployed or younger individuals, uptake remains overall low with lower level of uptake among men (Baisley et al., 2019). To address the latter, a recent clinical trial (the Home-Based Intervention to Test and Start (HITS) clinical trial) has been conducted to investigate the use of CFI to increase home-based HIV testing uptake among men in rural South Africa (Mathenjwa et al., 2019). The preliminary results of that trial have shown that a CFI increased testing uptake by 55% among men (Tanser et al., 2021). Yet, whether the CFI was able to reduce home-based HIV testing uptake gaps based on gender or other socio-demographic characteristics has not been explored. Such analysis is important to ensure that combining a CFI with home-based HIV testing contributes to higher testing uptake among those with less access to HIV testing. Using the HITS clinical trial dataset, we aim to investigate whether a CFI was able to reduce home-based testing uptake inequalities observed by socio-demographic groups by (i) measuring the effect CFI on existing socio-demographic differentials and (ii) assessing whether the effect of CFI was different depending on socio-demographic characteristics of individuals.

2. Methods

2.1. Setting

The study was conducted in the Africa Health Research Institute (AHRI) demographic surveillance system which provides an annual population-based HIV survey and census of people residing in the uMkhanyakude district in KwaZulu-Natal, South Africa (Gareta et al., 2021). The area is primarily rural, though also has a number of smaller communities with denser housing, and one large town, which young people often migrate to. Overall, across the area there are high levels of unemployment with only 18% of those aged 18–35 years who are out of school in full-time employment, and two-thirds of households receive social grants. There are also high levels of circular-migration to larger urban centres and vice versa.

2.2. Data

We conducted a secondary analysis using data from the HITS clinical trial (Clinical Trial Number: NCT03757104) which was a 2 × 2 factorial design cluster-randomized clinical trial embedded in the AHRI's ongoing population-based HIV surveillance. One of the aims of the trial was to measure the impact of two interventions (a CFI and a male-targeted HIV-specific decision support application, called EPIC-HIV —Empowering People through Informed Choices for HIV) on home-based HIV testing uptake and linkage to HIV care among the general population. 45 clusters were randomized into 4 arms: (i) CFI (8 clusters), (ii) EPIC-HIV (8 clusters), (iii) CFI and EPIC-HIV (8 clusters), (iv) control (21 clusters). A full description of the trial design has been published elsewhere (Mathenjwa et al., 2019).

2.3. Eligibility criteria

All residents aged ≥15 years who have participated to the AHRI's population-based HIV surveillance survey, conducted from January 1, 2018 to December 31, 2018, were eligible to participate in the HITS trial. The intervention activities and data collection related to the HITS clinical trial were integrated into the 2018 annual AHRI's population-based HIV surveillance visit. People who self-reported both being HIV-positive and being already on ART were not eligible for the trial; those who self-reported being HIV-positive but not currently on ART (never been or who have interrupted their treatment) were eligible for the trial. Those individuals who tested HIV-positive by the rapid-test were eligible to receive a second intervention to increase linkage to ART which was not considered in this analysis but has been described elsewhere (Mathenjwa et al., 2019).

2.4. Control arm

All eligible individuals were invited to participate in the survey. Participants were offered a free home-based rapid HIV-test with an immediate result performed by a field worker.

2.5. Intervention arms

In the first arm, all eligible individuals accepting the free home-based HIV testing were given a food voucher of a value of 50 Rands (~3.5 US dollars). The value of the food voucher is equivalent to three times the individual daily 2019 Food poverty line (i.e., the amount of money that an individual will need to afford the minimum required daily energy intake) (Stats, 2020). A previous study conducted in rural Malawi, in a similar context to our study, showed that the effect of the total amount of an incentive does not change over a 1.5–3.0 US dollar value (Thornton, 2008).

In the second arm, men were offered the EPIC-HIV application, which included tailored information to raise awareness of the benefits of knowing their HIV status and linkage to care if diagnosed with HIV. The third arm combined the interventions of the first two arms. Individuals were informed about both interventions prior to their participation.

2.6. Data collected

Socio-demographic (e.g., sex, age, education, employment status, household assets index) and geographical (e.g., distance from nearest clinic, urban/rural living area) data were collected for each individual. The selection of these variables was based on existing work showing HIV testing inequalities linked to individuals' socio-demographic and geographic characteristics (National Department of Health [South Africa], 2019; Venkatesh et al., 2011; Baisley et al., 2019). Where available, missing data on socio-demographic characteristics were completed from the previous data surveillance round that occurred less than one year before the trial.

The household assets index was obtained using a component analysis of data on house ownership, energy, water source, electricity, toilet type and 27 other household assets based on Filmer and Pritchett works (Filmer and Pritchett, 2001). This variable categorized households as poorest 40%, middle 40% or the wealthiest 20%. We choose these three categories because they have been found to capture wealth effect well in several economical and health surveys within poor provinces in South Africa (Bärnighausen et al., 2007; Berg and Louw, 2005; Booysen, 2002).

Home-based HIV testing uptake was defined as the acceptance of the testing offer and its performance by a field worker.

2.7. Statistical analysis

Since the focus of this analysis was on the effect of the CFI intervention, and because EPIC-HIV had no effect on HIV testing uptake (Tanser et al., 2021), the EPIC-HIV and CFI arm was grouped with the CFI arm only and the EPIC-HIV alone was grouped with the control arm (i.e. non-CFI arms). The analysis was conducted among all individuals contacted even if they did not participate in the HIV surveillance. Analyses were stratified by sex as HIV testing uptake and related barriers can greatly vary according to gender (Obermeyer and Osborn, 2007).

To measure the effect of using a CFI on existing socio-demographic differentials in home-based HIV testing uptake, we computed the absolute differences in uptake of home-based HIV testing between CFI and non-CFI arms for each socio-demographic characteristic.

To assess whether the effect of CFI was different depending on socio-demographic characteristics, we computed the relative risk factors associated with home-based HIV testing uptake among individuals depending on intervention arm. Relative risk factors were investigated by running a modified Poisson regression model with a logarithm link function adjusted for community-level clustering and binary outcomes through clustered sandwich estimators (Royall, 1986; Zou, 2004). The interaction terms between home-based HIV testing uptake and each socio-demographic variable were computed to measure any change in the effect of the CFI between two socio-demographic groups. Multivariate models included all variables but only interaction terms significant to the $p \leq 0.2$ threshold in the univariate analysis. Statistical tests were performed using likelihood-ratio tests.

All analyses were conducted in R 3.6.3. With the packages *sandwich* for the models' estimators and related confidence intervals and the package *survey* for the cluster-adjusted confidence intervals of descriptive results (Zeileis et al., 2020; Lumley, 2004).

2.8. Ethical approval and consent to participate

Participant were informed about the clinical trial prior their participation in the AHRI's population-based HIV surveillance survey and reminded their right to decline the home-based HIV testing. Rapid tests were conducted at the home of the participant or any close area where confidentiality could be maintained. Participants were not asked to disclose the results of their test to anyone. The trial has been conducted with the AHRI's ongoing population-based HIV surveillance platform which received approval by the Biomedical Research Ethics Committee of the University of KwaZulu-Natal (BE290/16). Additional ethical approval specific to the HITS intervention was received on June 28, 2017 (BFC398/16). The trial is being conducted with permission from the KwaZulu-Natal Department of Health, South Africa. Written informed consent is sought from individuals aged 18+ and parental/guardian consent with individuals 15–17 years old.

3. Results

Overall, the 45 clusters included 37,028 individuals (Fig. 1A). Among them 3252 (1591 men and 1661 women) were excluded because they died or out-migrated during the study period. Thus, 13,893 men and 19,883 women were eligible to participate in the AHRI HIV surveillance survey round. Among them, 8188 individuals (24.2%) were not contacted because they were not at home during the survey round visit and were thus excluded from our analysis. Compared to those contacted, non-contacted individuals were more likely to be men, younger (among men), older (among women), to report no education or primary education and not currently working (Table S1, supplementary material).

Among the 25,588 contacted individuals, 61.3% have participated in the AHRI HIV surveillance and were offered participation in the survey (Fig. 1B). Participation in the AHRI data surveillance was higher in the CFI arms compared to non-CFI arms (67.8% vs 58.1%, $p < 0.001$).

Among the 25,588 contacted individuals, 795 individuals were removed due to missing data (testing uptake or demographic characteristics). Therefore, 24,793 individuals have been included in our analysis on testing uptake (9290 men and 15,503 women).

42.4% of our sample were over 40-years old. Women were older than men (average age: 42 vs 35 years old, $p < 0.001$) and they were also less likely to be single than men (28.8% vs 42.3%, $p < 0.001$) (Table 1). Most of our sample lived in a rural area (59.3%) and a quarter (23.5%) lived more than 4 km from the nearest clinic.

Effect of CFI on existing socio-demographic differentials in home-based HIV testing uptake.

CFI significantly increased home-based HIV testing uptake among both men (39.2% vs 25.2%, $p < 0.001$) and women (45.9% vs 32.0%, p

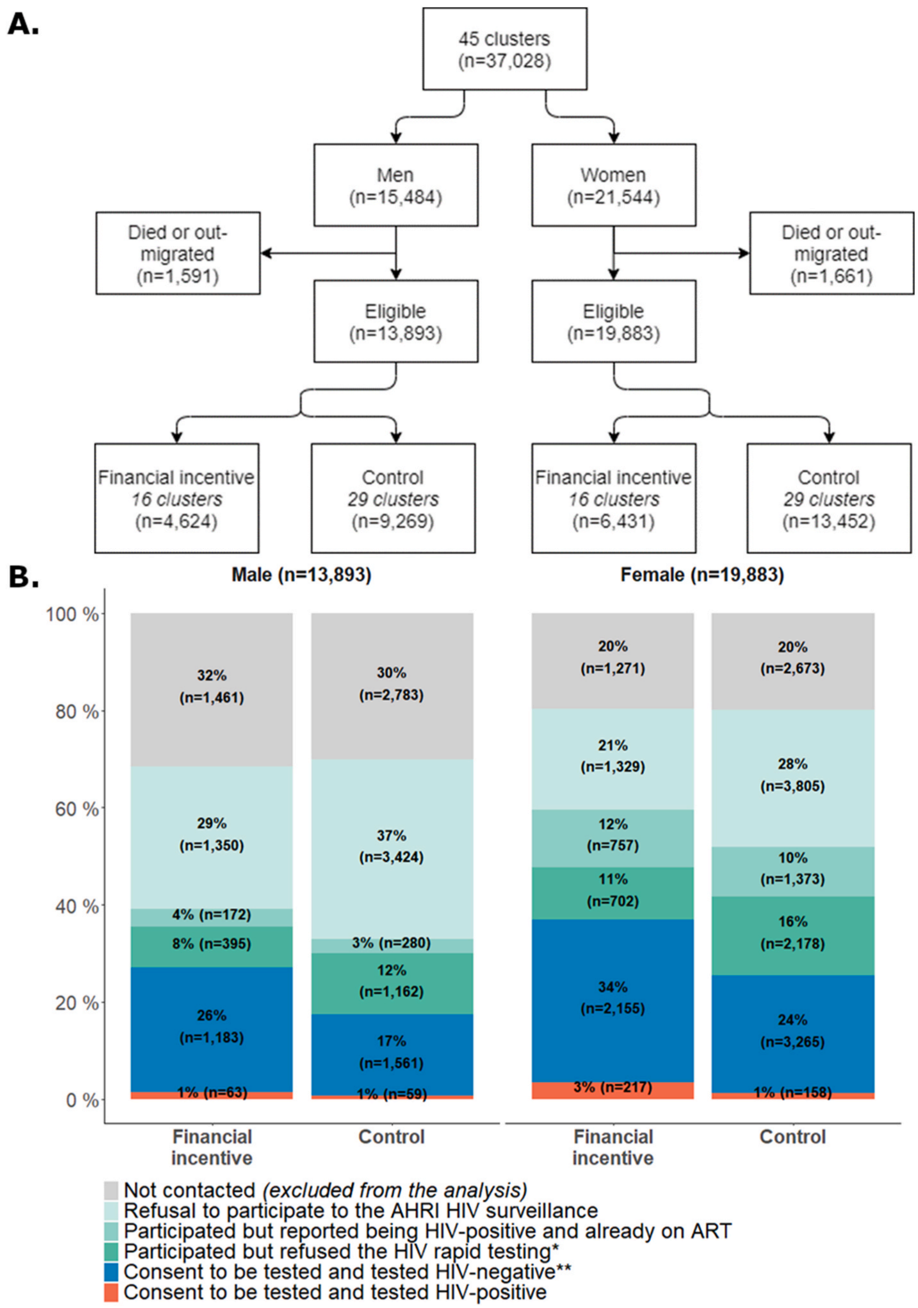

Fig. 1. Flow chart of eligible individuals included in the trial (A) and description of eligible people depending on whether they have been contacted, participated and consented to be HIV rapid tested depending on test result (B). EPIC-HIV: male-targeted HIV-specific decision support application.

< 0.001). Home-based HIV testing uptake was higher among women compared to men in the non-CFI arms (32.0% vs. 25.2%, $p < 0.001$); however, the absolute percentage increase for uptake in the CFI arm was similar (13.9%, 95% Confidence Interval: [11.2–16.6] vs. 14.0% [11.6–16.4] among women and men, respectively) resulting in an absolute differential increase between women and men close to 0 (0.08% [−3.6–3.7]). That is, the CFI did not significantly increase the existing gender difference in home-based HIV testing uptake observed in the non-CFI arm.

The difference in home-based HIV testing uptake between young and older and the difference in home-based HIV testing uptake between more and less educated men and women increased in the CFI arm compared to the non-CFI arm among both men and women. In the non-CFI arm, home-based HIV testing uptake was higher among under 20s in both men and women compared to those 40 years old and over (Fig. 2), whereas the CFI arm increased the difference by 7.4 points (95%CI [1.5–13.3]) among men and 10.1 points [4.5–15.6] among women (Tables 2 and 3). Uptake in the non-CFI arm was higher among men and women with no education or just primary education compared to those with higher education (among men, 33.1% vs 12.3%, $p < 0.001$, and among women, 41.9% vs 14.6%, $p < 0.001$) and this difference increased by 11.8 points [6.4–17.3] among men and 7.2 points [3.0–11.4] among women.

Among men, marital and employment status difference in home-based HIV testing uptake increased in the CFI arm compared to the non-CFI one. Increase in the CFI arm was higher among single compared to those married or in a union (18.4%, 95%CI [14.7–22.1] vs 5.5% [−2.0–13.0] respectively, Table S1). Testing uptake in the non-CFI arm was higher among men not currently working (29.8% vs 14.6%, $p <$ 0.001) and this difference increased by 15.7 points [12.8–18.6] in the

Table 1
Sample description.

	Contacted			
	Men (n = 9049)		Women (n = 15,280)	
	N	%	N	%
Age (years)				
Under 20	2141	**23.0**	1997	**12.9**
20–29	2401	**25.8**	3184	**20.5**
30–39	1735	**18.7**	2811	**18.1**
40 and over	3013	**32.4**	7511	**48.4**
Education				
Never went to school/Primary	3826	**41.2**	6602	**42.6**
Secondary	4828	**52.0**	7630	**49.2**
Tertiary	636	**6.8**	1271	**8.2**
Marital situation				
Single	3933	**42.3**	4459	**28.8**
Married/Informal union	5146	**55.4**	8473	**54.7**
Widowed/Separated/Divorced	211	**2.3**	2571	**16.6**
Household assets index				
40% poorest	3628	**39.1**	6125	**39.5**
40% wealth middle	3771	**40.6**	6395	**41.3**
20% richest	1891	**20.4**	2983	**19.2**
Professional situation				
Currently employed	2788	**30.0**	3180	**20.5**
Not Employed	6502	**70.0**	12,323	**79.5**
Area of residency				
Rural	5417	**58.3**	9288	**59.9**
Peri-urban	3206	**34.5**	5063	**32.7**
Urban	667	**7.2**	1152	**7.4**
Distance from nearest clinic				
4 km or below	7122	**76.7**	11,853	**76.5**
>4 km	2168	**23.3**	3650	**23.5**

CFI arm. Testing differentials between men currently working and those who did not was also higher in the CFI arm (6.9 points [3.3–10.5]).

Increase in CFI arm was similar for household assets index, area type and distance from the nearest clinic among both men and women.

Effect of CFI on socio-demographic characteristics of home-based HIV testing acceptors.

Fig. 3 presents the relative risk factors with HIV testing uptake in each arm (CFI and non-CFI) by sex and the individual interaction p-value for each interaction term. Risk ratios indicate groups of individuals more likely to accept the home-based HIV testing, while the interaction term indicate is there is a significant relative change between the CFI group compared to the non-CFI. The latter is of interest for us as it shows whether the characteristics of individuals accepting the home-based HIV testing are similar or not without or without CFI.

Among men, no individual and global interaction terms were significant to the 0.05 threshold which indicates that the CFI arm does not modify the association between testing uptake and socio-demographic characteristics (for the individual p-value see Fig. 3 and for the global p-value, see Table 4). Therefore, the socio-demographic profile of home-based HIV testing acceptors was similar between men in the CFI and those in the non-CFI arm. The CFI had a higher effect on testing uptake among men living in peri-urban areas but not significantly (vs those living in rural areas Risk Ratio (RR) 1.24, 95%CI [0.98–1.56], $p = 0.070$).

Among women, the CFI arm had a higher effect on testing uptake among those 30–39 years old (vs under 20, RR 1.15, 95%CI [0.94–1.41], $p = 0.166$), those with a secondary education (vs no or primary education, RR 1.12 [1.03–1.23], $p = 0.012$) and among women who were employed (RR 1.24 [1.05–1.47], $p = 0.012$) [Fig. 3, Table 4]. In the multivariate model, interaction between CFI arm with age and employment status were still globally significantly associated but the level of education was not (Table 4).

When considering both men and women on the same model, the CFI arm had a lower effect on testing uptake among women close to the 0.05 threshold (vs men, RR 0.92 [0.84–1.01], $p = 0.095$) (Table S3).

4. Discussion

For this study, we considered both the absolute and relative effect of CFI on existing socio-demographic inequalities for home-based HIV testing uptake in a rural context in South Africa. Our results show that a CFI does increase home-based HIV testing overall uptake, but individuals accepting the testing offer share the same socio-demographic characteristics regardless of the CFI introduction. In other words, a CFI accentuates existing differences in that health behaviour adoption between socio-demographic groups rather than correcting them.

In our study, the sub-populations more likely to respond to the CFI were also those more likely to accept the home-based HIV testing without CFI. HIV testing uptake was higher among younger or less educated, in both men and women, and among single or unemployed men. In addition, these groups have a higher absolute home-based HIV testing uptake increase compared to other groups (i.e. older, more

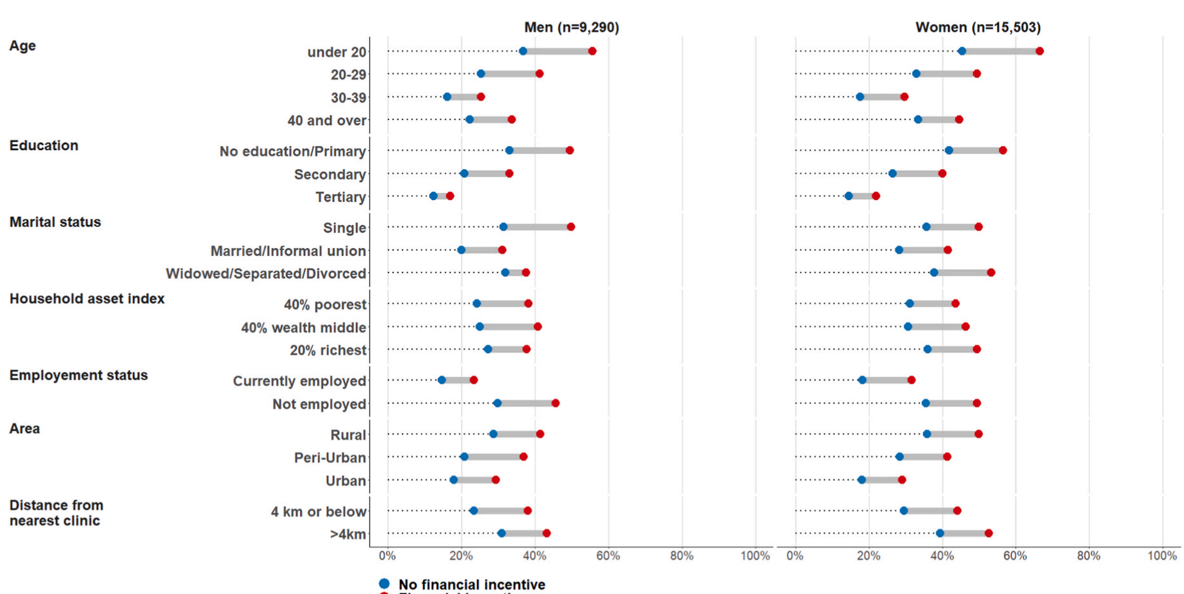

Fig. 2. Percentages of home-based rapid-HIV testing uptake among men and women who have been contacted for trial participation by socio-demographic characteristics and arms. Note: the grey area between the dots highlights the differentials between arms.

Table 2
Testing uptake, difference within group and differential increase between CFI arms and non-CFI arms, among men (n = 9290).

	Testing uptake (%)		Uptake difference within group (%)		Differential increase (%) (C)-(D)	Differential increase 95%CI
	CFI arm (A)	Non-CFI arm (B)	CFI arm (C) = *ref* (A)-(A)	Non-CFI arm (D) = *ref* (B)-(B)		
Age						
under 20	55.6	36.7	*ref*	*ref*	*ref*	
20–29	41.3	25.3	14.3	11.3	3.0	[-2.6– 8.5]
30–39	25.3	16.1	30.3	20.6	9.7	**[4.1–15.3]**
40 and over	33.7	22.2	21.9	14.5	7.4	**[1.5–13.3]**
Education						
No education/ Primary	49.5	33.1	*ref*	*ref*	*ref*	
Secondary	33.1	20.8	16.4	12.3	4.1	**[0.1–8.1]**
Tertiary	16.9	12.3	32.7	20.8	11.8	**[6.4–17.3]**
Marital Status						
Single	49.9	31.5	*ref*	*ref*	*ref*	
Married/ Informal union	31.1	20.0	18.8	11.5	7.4	**[3.1–11.6]**
Widowed/ Separated/ Divorced	37.5	32.0	12.4	−0.5	12.9	**[4.5–21.2]**
Household assets index						
40% poorest	38.3	24.2	*ref*	*ref*	*ref*	
40% wealth middle	40.8	25.0	−2.5	−0.8	−1.7	[-5.8– 2.4]
20% richest	37.8	27.2	0.5	−3.0	3.5	[-0.6– 7.6]
Currently employed						
Not employed	45.6	29.8	*ref*	*ref*	*ref*	
Currently employed	23.4	14.6	22.1	15.2	6.9	**[3.3–10.5]**
Area type						
Rural	41.4	28.7	*ref*	*ref*	*ref*	
Peri-Urban	36.9	20.7	4.5	8.0	−3.5	[-7.6– 0.6]
Urban	29.3	17.8	12.1	10.9	1.3	[-3.6– 6.2]
Distance to the nearest Clinic						
4 km or below	38.1	23.3	*ref*	*ref*	*ref*	
>4 km	43.2	30.9	−5.1	−7.6	2.4	[-2.9– 7.7]

Table 3
Testing uptake, difference within group and differential increase between CFI arms and non-CFI arms, among women (n = 15,280).

	Testing uptake (%)		Uptake difference within group (%)		Differential increase (%) (C)-(D)	Differential increase 95%CI
	CFI arm (A)	Non-CFI arm (B)	CFI arm (C) = *ref* (A)-(A)	Non-CFI arm (D) = *ref* (B)-(B)		
Age						
under 20	66.6	45.4	*ref*	*ref*	*ref*	
20–29	49.5	32.9	17.2	12.6	4.6	[-0.9–10.0]
30–39	29.8	17.6	36.8	27.8	9.0	**[3.8–14.2]**
40 and over	44.6	33.5	22.0	11.9	10.1	**[4.5–15.6]**
Education						
No education/ Primary	56.5	41.9	*ref*	*ref*	*ref*	
Secondary	40.1	26.5	16.4	15.4	1.0	[-2.8– 4.8]
Tertiary	22.0	14.6	34.4	27.3	7.2	**[3.0–11.4]**
Marital Status						
Single	50.0	35.7	0.0	*ref*	*ref*	
Married/ Informal union	41.6	28.2	8.4	7.4	1.0	[-3.2– 5.2]
Widowed/ Separated/ Divorced	53.3	37.8	−3.3	−2.1	−1.1	[-6.2– 4.0]
Household assets index						
40% poorest	43.6	31.2	*ref*	*ref*	*ref*	
40% wealth middle	46.4	30.7	−2.8	0.5	−3.3	[-7.6– 1.0]
20% richest	49.5	36.1	−5.9	−4.9	−1.0	[-5.3– 3.2]
Currently employed						
Not employed	49.5	35.5	*ref*	*ref*	*ref*	
Currently employed	31.7	18.3	17.8	17.2	0.6	[-3.3– 4.5]
Area type						
Rural	49.9	35.8	*ref*	*ref*	*ref*	
Peri-Urban	41.4	28.4	8.5	7.5	1.0	[-3.0– 5.1]
Urban	29.1	18.1	20.9	17.7	3.2	[-0.6– 6.9]
Distance to the nearest Clinic						
4 km or below	44.1	29.5	*ref*	*ref*	*ref*	
>4 km	52.6	39.5	−8.6	−9.9	1.4	[-2.8– 5.5]

educated individuals, married or employed men). Although older, higher educated individuals, married or employed men were less likely to accept the testing offered in our study, previous research suggests that these groups have better access to HIV testing in South Africa (National Department of Health [South Africa], 2019; Venkatesh et al., 2011). These groups may already have access to HIV testing by other means (e.g. voluntary HIV testing centre, testing offered at work) or may already have tested HIV positive and thus have no need to re-test, which could explain the home-based HIV testing refusal even when the testing is promoted with a CFI. Then, if the CFI did not reduce existing inequalities for home-based HIV testing uptake within our population study, the fact that the CFI enable the intervention to reach a higher proportion of the sub-populations known as having low access to other HIV testing services could, in fact, result in fewer inequalities in access to HIV testing.

The second important result of our study is to show the accentuating effect of CFI on existing socio-demographic differences for a health behaviour. This result could be explained by the fact that CFI prompts action by reducing psychological bias (i.e., present biasedness) but does not remove other existing barriers (e.g., perceived benefits) which can explain why some subgroups of a population are less likely to adopt a health behaviour event in the presence of a CFI. Thus, future health interventions should carefully assess the existing barriers and socio-demographic characteristics of the intervention recipients first before introducing a CFI to avoid the increase of existing health inequalities. An alternative approach to avoid an increase in health inequalities would be to offer CFI to targeted sub populations with poorer health outcomes (Oliver and Brown, 2012; Tarasiuk et al., 2012).

Through this study we addressed a gap in the literature on the effect of CFI on health inequalities which remains poorly documented especially in the African context (Oliver and Brown, 2012). Overall, the socio-demographic profile of people accepting the home-based HIV testing was similar between those offered CFI and those not offered CFI which is consistent with available studies in the US and UK that show few or no links between socio-demographic characteristics and effect of

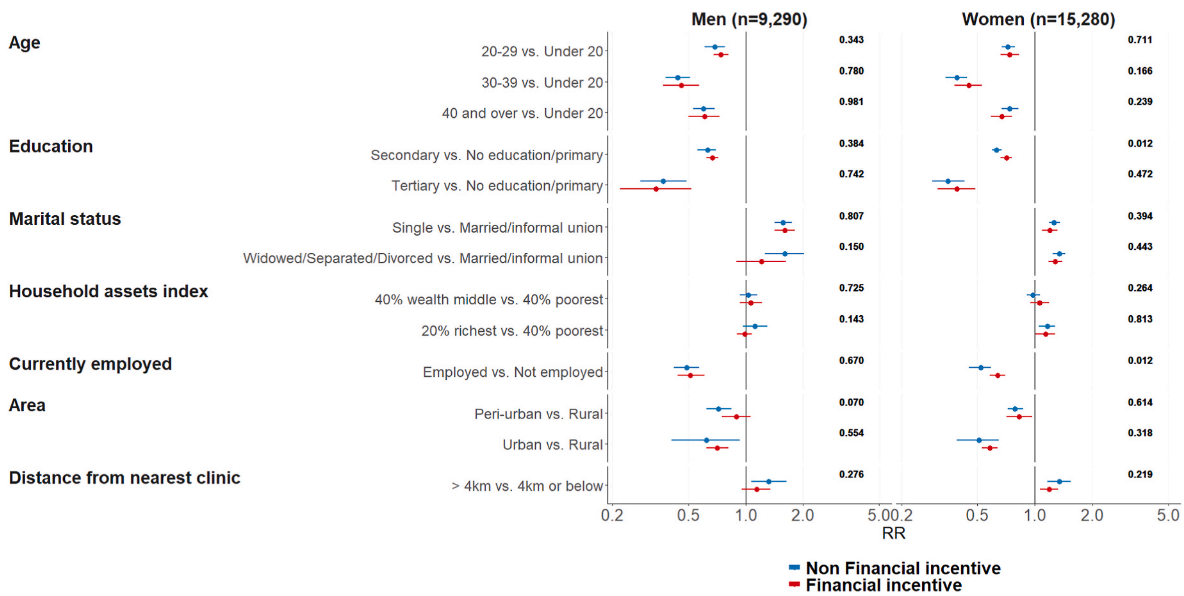

Fig. 3. Univariate analysis of risk factors associated with home-based HIV testing uptake among contacted individual depending on intervention arm. Note: p-value indicated are the likelihood-ratio test for the interaction.

CFI on different health behaviours (Haff et al., 2015; Mantzari et al., 2015). However, differential effects were found among two sub-groups. First, older women were less likely to respond to the CFI for testing uptake; this could be explained by the fact that women and older people are shown to be less present-biased for health behaviour adoption (Hunter et al., 2018). Second, we found a higher effect of the CFI among employed women; employed women may be more likely to accept the CFI as it could compensate income loss due to the time devoted to completing the survey. While the lack of differential CFI effects between subgroups suggests that the CFI mechanism operates in these groups through a behavioural effect (i.e. prompted by the immediate benefit of the reward), the higher CFI effect in young or employed women could be explained more by the income effect mechanism of CFI (i.e. the financial value that CFI represents). If the diminishing marginal utility of income (i.e., more income impacts less) is well known in the economic literature on CFI (Thornton, 2008; Vlaev et al., 2019), the differential CFI effect between specific groups is less documented and might reflect on the differential perception of the value of money induced by the high economic inequalities of some contexts (Ndimande, 2001; Bosch and Barit, 2020). However, from our results, it is difficult to know if decreasing or increasing the size of the financial incentive would have had any impact on the differential CFI effect observed in specific groups in our sample.

Our results have shown no associations between household asset index and CFI, although our study took place in a relatively poor society overall (two third of the households benefiting from social grants) which may have overestimated the CFI effect on individuals living in households with a high asset index. Yet, a study conducted in the US suggested that small CFI has a significant effect regardless of individual wealth (Haff et al., 2015). Unlike price signals (e.g. taxes on alcohol, cigarettes or high-calories foods) which is shown to have a higher effect on lower socio-economic populations (Powell and Chaloupka, 2009; Townsend et al., 1994), CFI may be a useful tool when the health inequalities are not based on economic status.

That said, there were a number of limitations in our study. Firstly, we excluded individuals who were not contacted through the AHRI based surveillance, who represent less than a quarter of the total sample. Using data from previous HIV surveillance rounds, people not contacted tend to be older (men), young (women), higher educated or those currently employed. Because of the study design of the HIV surveillance system, non-resident such as migrants or people with mobile livelihoods were also excluded from our analysis.

The initial design considered four arms among men with two including a male-targeted HIV-specific decision support application (EPIC-HIV). For statistical power considerations, we chose to group the arm with both the EPIC-HIV and the CFI with the financial incentive arm and the arm with EPIC-HIV only with the control arm, but considering the little effect of EPIC-HIV on home-based HIV testing (Tanser et al., 2021), we believe this grouping had little effect on our results.

Despite these limitations, our large sample and the randomized control trial design of the study allow strong internal validity of our results. Randomization in our study achieved balance in respect of sociodemographic variables across the different arms of the trial (Tanser et al., 2021).

People still express some objections toward CFI utilisation for health behaviour change. A common one is that the financial incentive could be seen as coercion if people who were reluctant to adopt a behaviour were persuaded by the CFI, which may represent something of high value (Deren et al., 1994). First, by showing the non-association between socio-economic condition and effect of CFI, our study suggests that the poorest people may not be more likely to feel coerced to adopt the behaviour because of the financial reward compared to the richest. Second, as argued by Burns, lauding the transparency of financial incentive programmes, by insisting on the voluntary basis to adhere to such programmes and to remind that the individual is free to accept or refuse the incentive for any reason, supports a mode of respectful and equal exchange rather than a way to manipulate people to do what the CFI wishes them to do (Oliver and Brown, 2012; Burns, 2007). The voluntary nature is commonly questioned when an economic reward is offered to the most deprived, but since the value of the CFI remains modest, and considering previous arguments, we believe that CFI is not likely to undermine an individual's view on what choice is in their best interest.

Further research on CFI and testing uptake are required especially related to the economical sustainability and the long-term effect on uptake behaviours of such intervention. While CFI has been showed to be cost effective for other health behaviours (Boyd et al., 2016; Lee et al., 2019), each health behaviour has their specific effects on health. The cost-effectiveness of CFI use to encourage testing uptake should be assessed with regards to local epidemiologic contexts. In addition, while studies tend to show that one-off CFI is not effective for long-term behaviours adoption (Thirumurthy et al., 2019; Yotebieng et al., 2016), the impact of a one-off CFI on future non-incentivise testing offer

Table 4
Univariate and multivariate analysis of risk factors associated with home-based HIV testing uptake among men and women.

	Men (n = 9290)						Women (n = 15,280)					
	Univariate			Multivariate			Univariate			Multivariate		
	RR	**CI95%**	p-value	RRa	**CI95%**	p-value	RR	**CI95%**	**pvalue**	RRa	**CI95%**	**p-value**
Arm			**<0.001**			**<0.001**			**<0.001**			**<0.001**
Control	*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*	
Financial incentive	1.56	[1.45–1.68]		1.47	[1.20–1.81]		1.43	[1.36–1.51]		1.46	[1.25–1.69]	
Age			**<0.001**			**<0.001**			**<0.001**			**<0.001**
Under 20	*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*	
20–29	0.71	[0.65–0.77]		0.89	[0.82–0.97]		0.72	[0.68–0.78]		0.80	[0.73–0.87]	
30–39	0.44	[0.39–0.50]		0.71	[0.61–0.83]		0.41	[0.37–0.45]		0.49	[0.42–0.56]	
40 and over	0.60	[0.54–0.68]		0.81	[0.72–0.91]		0.70	[0.65–0.77]		0.75	[0.68–0.83]	
Education			**<0.001**			**<0.001**			**<0.001**			**<0.001**
Never went to school/Primary	*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*	
Secondary	0.64	[0.60–0.69]		0.82	[0.76–0.88]		0.67	[0.63–0.7]		0.78	[0.73–0.82]	
Tertiary	0.35	[0.27–0.45]		0.56	[0.45–0.70]		0.35	[0.3–0.42]		0.54	[0.46–0.63]	
Marital situation			**<0.001**			**0.023**			**<0.001**			**<0.001**
Single	1.59	[1.46–1.72]		1.11	[1.01–1.22]		1.24	[1.17–1.31]		0.91	[0.87–0.96]	
Married/Informal union	*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*	
Widowed/Separated/Divorced	1.42	[1.18–1.71]		1.21	[0.99–1.47]		1.31	[1.23–1.39]		1.08	[1.01–1.16]	
Household assets index			0.474			0.288			**0.001**			**0.009**
40% poorest	*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*	
40% wealth middle	1.07	[0.96–1.19]		1.06	[0.96–1.17]		1.15	[1.06–1.24]		1.04	[0.99–1.09]	
20% richest	1.04	[0.95–1.14]		1.07	[0.92–1.24]		1.02	[0.94–1.10]		1.11	[1.04–1.19]	
Professional situation			**<0.001**			**<0.001**			**<0.001**			**<0.001**
Currently employed	0.50	[0.44–0.55]		0.66	[0.59–0.74]		0.56	[0.51–0.62]		0.69	[0.60–0.79]	
Not Employed	*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*	
Area of residency			**0.006**			**0.001**			**<0.001**			**<0.001**
Rural	*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*	
Peri-urban	0.81	[0.68–0.97]		0.82	[0.70–0.95]		0.82	[0.73–0.93]		0.92	[0.84–1.00]	
Urban	0.61	[0.42–0.87]		0.77	[0.53–1.14]		0.50	[0.38–0.65]		0.68	[0.60–0.78]	
Distance from nearest clinic			**0.021**			0.339			**<0.001**			**0.018**
4 km or below	*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*		*ref.*	*ref.*	
>4 km	1.23	[1.03–1.46]		1.07	[0.93–1.24]		1.26	[1.13–1.41]		1.11	[1.02–1.21]	
Interaction with arm												
Age 20–29	1.08	[0.93–1.25]	0.738				1.03	[0.89–1.18]	**0.010**	0.98	[0.85–1.12]	**0.005**
Age 30–39	1.04	[0.80–1.35]					1.15	[0.94–1.41]		1.08	[0.87–1.32]	
Age 40 and over	1.00	[0.80–1.26]					0.91	[0.77–1.07]		0.87	[0.76–1.00]	
Education Secondary	1.06	[0.93–1.22]	0.643				1.12	[1.03–1.23]	**0.041**	1.04	[0.95–1.13]	0.643
Education Tertiary	0.92	[0.55–1.53]					1.12	[0.83–1.51]		0.94	[0.72–1.23]	
Marital status Single	1.02	[0.87–1.20]	0.326				0.95	[0.85–1.07]	0.590			
Marital status Widowed/ Separated/Divorced	0.76	[0.52–1.11]					0.96	[0.85–1.07]				
Household assets index 40% wealth middle	1.03	[0.87–1.22]	0.127	1.00	[0.85–1.16]	0.249	1.08	[0.94–1.24]	0.399			
Household assets index 20% richest	0.88	[0.74–1.04]		0.89	[0.75–1.05]		0.98	[0.84–1.14]				
Professional sit. Currently employed	1.05	[0.84–1.31]	0.670				1.24	[1.05–1.47]	**0.012**	1.21	[1.03–1.43]	**0.023**
Area of residency Peri-urban	1.24	[0.98–1.56]	0.193	1.22	[0.97–1.54]	0.227	1.05	[0.87–1.26]	0.597			
Area of residency Urban	1.14	[0.74–1.75]		1.11	[0.74–1.67]		1.15	[0.87–1.52]				
Distance from nearest clinic >4 km	0.86	[0.65–1.13]	0.276				0.89	[0.75–1.07]	0.219			

Note: p-value mentioned in this table are global p-value. They were computed using Wald test.

acceptation remain undocumented. This last question is quite important as regular repeat HIV testing is recommended in high HIV incidence settings (WHOUNAIDS, 2007).

5. Conclusion

Associating a CFI with an invitation for home-based HIV-testing intervention increases the overall HIV-testing uptake. However, this association leads to an increase in the existing socio-demographic differences in testing uptake. Future intervention involving CFI should consider its effect based on socio-demographic disparities of recipients to prevent any increase in existing inequalities in health behaviours.

Credit author statement

FT and TB are the principal investigators and developed the study design and protocol in collaboration with MS, SW, NM, JS, HMY, BS and AD. TM contributed to the implementation of the study. HYK cleaned and prepared the data. MI analysed the data and wrote the first draft of the manuscript. All authors read, edited and approved the final manuscript.

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Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the article.

Declaration of competing interest

The authors declare no conflicts of interest.

Data availability

The de-identified datasets are available upon reasonable request through the Africa Health Research Institute (AHRI) data repository at https://data.ahri.org/index.php/home.

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Appendix A. Supplementary data

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