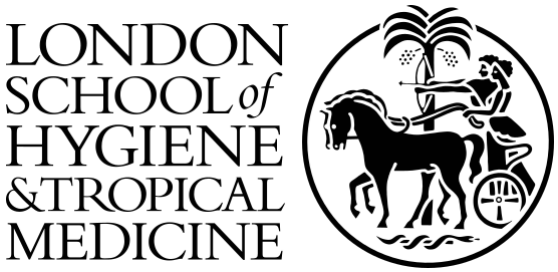


Annexes

Annex 1: Additional Information on the BHOMA Intervention

BHOMA aims to improve the delivery of primary health care services by strengthening the public health care system and improving the community's trust in the capacity of their local health facility to deliver quality care. BHOMA's primary outcomes are all cause age-adjusted and under-5 mortality (1). BHOMA works through the district health offices to implement two interventions: one at the level of the health facility and one at community-level (1, 2). At health facilities, BHOMA aims to improve care provision through the implementation of practical tools that emphasise clear standards of care, ensuring facilities have the resources required to meet these standards, ongoing measurement of clinical performance and mentoring and supervision to support the maintenance of these standards. BHOMA provides facilities with necessary diagnostic equipment, essential medicines and supplies, additional human resources and improved infrastructure.

At community level, BHOMA recruited additional community healthcare workers (CHW) to encourage improved linkage to health facility and follow-up of patients already engaged with services. BHOMA provides CHW with comprehensive training, ongoing supervision, appropriate resources and financial incentives. Standards of care and referrals have been established through the use of patient follow-up, household assessment forms and of mobile phone technology.

Implementation commenced in 2012 and continued through 2013. BHOMA was implemented in seven steps, with six randomly selected clusters targeted in each step. Implementation was led by the Centre for Infectious Disease Research in collaboration with the Catholic Medical Mission Board and the Ministry of Health through district health offices. The BHOMA evaluation, which is being conducted by ZAMBART, commenced in 2011, with baseline population and health facility surveys conducted in each cluster prior to the implementation of the interventions.

Annex 2. Household enumeration form

BHOMA Community Survey: Household Management Form
Clinic:

FORM 1 – Front side

Visit Date:	Visit Time: :
Household Consent Y/N:	Address:
	Square:

SEQ.NO.	24 [1]	23 [1]	22 [1]	21 [1]	20 [1]	19 [1]	18 [1]	17 [1]	16 [1]	15 [1]	14 [1]	13 [1]	12 [1]	11 [1]	10 [1]	9 [1]	8 [1]	7 [1]	6 [1]	5 [1]	4 [1]	3 [1]	2 [1]	1 [1]	FIRST NAME	SURNAME	HOH (Y/N)	SEX (M/F)	AGE	MARRIED TO [2]	CHILD TO [3]	CONSENT [4]	CHILD LAST 2 YRS [5]	MOSQ.NET (Y/N)	INDIVIDUAL BARCODE	PDA-NO	TAKEN TO HHC
1																																			Date of Death Cause of Death During Pregnancy? During/After Childbirth?		
2																																			Date of Death Cause of Death During Pregnancy? During/After Childbirth?		
3																																			Date of Death Cause of Death During Pregnancy? During/After Childbirth?		
4																																			Date of Death Cause of Death During Pregnancy? During/After Childbirth?		
5																																			Date of Death Cause of Death During Pregnancy? During/After Childbirth?		

1) Indicate P = Present, A = Absent, D = Died
2) Indicate for only females, the serial number of spouse/husband/partner
3) Indicate for children <5years, the serial number of the BIOLOGICAL mother
4) Consent: Y=Consented, N=No Consent, E=Excluded (If HH Member is not eligible), A=Absent, D = Died
5) Y=Had a live birth in the last two years, N= Has not had a live birth in the last two years

Signed Off By	
Date	D D M M Y Y Y Y

Annex 3: Defining Socioeconomic Position Quintiles

I developed an indicator of SEP to explore whether SEP was associated with HIV-testing behaviours and to adjust for SEP when estimating the association between other independent variables and HIV-testing outcomes. I used Principal Components Analysis (PCA) on household survey data to derive the household SEP variable. PCA is a multi-variable data reduction method that allows one to develop uncorrelated indicators of a concept of interest based on a set of correlated variables (3). I opted to use PCA as it is commonly used in surveys collecting asset data, including DHS, and has been shown to be robust to the underlying assumptions of normality and is computationally straight forward (4).

Across both surveys I considered twenty-eight variables for inclusion (Table 1). To increase variability in the data, I excluded any asset variable for which ownership was low (<2%) or high (>98%). I developed a single wealth index for urban and rural clusters as few clusters were defined as urban and research suggests that creating separate indices by urban and rural residence often has little effect on the weights of variables and the distribution of the wealth scores (5). I explored the effect of creating separate indices for urban and rural households, however, as highlighted by Howe et al (2009), this had little effect on the wealth index. I ran the PCA separately at each survey round.

For households, I present the distribution of assets and housing quality among households with no missing data and the results of the PCA, including the weight assigned to each variable and the eigen value for the principal component. I present the distribution of the SEP scores and of SEP groups by urban and rural residence. I explored whether there was any evidence of clustering of households into small groups (referred to as “clumping”) or truncation, which is where scores are spread more evenly but over a narrow range making it difficult to distinguish between groups (3).

Table 1. Details of variables collected through the household questionnaire

	Variable description
Has radio	Whether a household has one or more radios
Has tv	Whether a household has one or more televisions
has_mobile	Whether a household has one or more mobile phones
has_nonmobile	Whether a household has one or more non-mobile phones
has_fridge	Whether a household has one or more fridges
has_bed	Whether a household has one or more beds
has_chair	Whether a household has one or more chairs
has_table	Whether a household has one or more tables
has_cupboard	Whether a household has one or more cupboards
has_sofa	Whether a household has one or more sofas
has_clock	Whether a household has one or more clocks
has_fan	Whether a household has one or more fans
has_sewmachine	Whether a household has one or more sewing machines
has_plough	Whether a household has one or more ploughs
has_vcrdvd	Whether a household has one or more VCR/DVDs
has_tractor	Whether a household has one or more boats
has_car	Whether a household has one or more cars
has_watch	Whether a household has one or more watches
has_bike	Whether a household has one or more bicycles
has_motorbike	Whether a household has one or more motorcycles
has_animal	Whether a household has one or more animal-drawn carts
has_boat	Whether a household has one or more boats
has_grinder	Whether a household has one or more grinders/hammer mills
Source of Drinking Water	Piped water into dwelling/own yard Communal tap Open well/borehole Covered or protected well/borehole Spring/river/pond/lake/rain Other
Toilet Facility	Flush to sewer system/septic tank/pit latrine/elsewhere VIP or latrine with/without slab No facility/bush/field Other
Type of Floor Material	Natural (Earth/sand; dung) Finished (Parquet/polished wood; Vinyl/asphalt strips; Ceramic/terrazo tiles; Concrete cement; Carpet) Rudimentary (Wood planks; Palm, bamboo, reeds) Other
External Wall Material	Natural (No walls; Cane/palm/trunks; Mud) Rudimentary/Other (Bamboo/pole & mud; Stone with mu; Plywood; Cardboard; Reused wood; Other) Finished (Cement; Stone with lime/cement; Bricks; Cement blocks) Other
Type of Roof Material	Natural (Earth/sand; dung) Rudimentary (Wood planks; palm/bamboo/reeds) Finished (Parquet/polished wood; Vinyl/asphalt strips; Ceramic/terrazo tiles; Concrete cement; Carpet) Other

3.1 Asset Ownership and Housing Characteristics of Participating Households

The PCA was run on 99% (n=5330) of households with no missing data in the 2011/12 survey and 99.7% (n=11997) of households in the 2013 survey (Table 2). The variable with the highest missing data was chair ownership (0.3% (n=18) in 2011/12 and 0.1% (n=15) in 2013). Over half the households in both surveys owned at least one radio (2011/12: n=2946, 55%; 2013: n=6750, 56%). More than 70% owned a mobile phone (2011/12: n=3844, 72%; 2013: n=9370, 78%). Few owned a car (2011/12: n=298, 6%; 2013: n=808, 7%) with more than 40% owning a bicycle (2011/12: n=2199, 41%; 2013: n=5226, 44%). A covered/protected well or borehole was the most common source of drinking water (2011/12: n=2057, 39%; 2013: n=5592, 47%). The majority of households had floors made of natural material (2011/12: n=3026, 57%; 2013: n=6156, 51%), and had finished roofs (2011/12: n=3388, 64%; 2013: n=8679, 72%) and external walls (2011/12: n=2963, 56%; 2013: n=7496, 63%).

Table 2. Distribution of Household Assets and Scoring Coefficient (weight) in PCA by population-based survey

	2011/12 (N=5330)		2013 (N=11997)	
	%, n	Weight	%, n	Weight
Has one or more radios	54.7 (2946)	0.16	56.3 (6750)	0.15
Has one or more televisions	36.2 (1969)	0.25	41.9 (5027)	0.26
Has one or more mobile phones	71.5 (3844)	0.18	78.1 (9370)	0.17
Has one or more beds	76.0 (4087)	0.16	78.0 (9357)	0.16
Has one or more chairs	41.6 (2232)	0.10	36.6 (4388)	0.09
Has one or more tables	56.4 (3043)	0.20	57.7 (6924)	0.20
Has one or more cupboards	32.4 (1748)	0.19	35.2 (4224)	0.20
Has one or more sofas	36.3 (1970)	0.23	40.1 (4810)	0.24
Has one or more clocks	19.5 (1053)	0.19	15.4 (1843)	0.19
Has one or more fans	8.0 (439)	0.19	8.9 (1072)	0.20
Has one or more sewing machines	6.3 (347)	0.11	5.5 (656)	0.10
Has one or more ploughs	6.8 (367)	0.02	6.2 (744)	0.02
Has one or more VCR/DVDs	22.8 (1242)	0.25	28.0 (3364)	0.25
Has one or more cars	5.4 (298)	0.14	6.7 (808)	0.16
Has one or more watches	9.0 (492)	0.08	7.6 (913)	0.10
Has one or more bicycles	41.0 (2199)	0.07	43.6 (5226)	0.04
Has one or more animal-drawn carts	3.3 (179)	0.01	2.6 (316)	0.02
Has one or more fridges	12.0 (662)	0.23	15.2 1828)	0.25
Household Drinking Water Source				
Piped water into dwelling/own yard	13.6 (727)	0.20	17.2 (2057)	0.22
Communal tap	15.2 (810)	0.05	11.2 (1343)	0.03
Open well/borehole	21.2 (1129)	-0.07	15.6 (1872)	-0.06
Covered or protected well/borehole	38.6 (2057)	-0.08	46.6 (5592)	-0.10
Spring/river/pond/lake/rain	10.4 (554)	-0.08	8.4 (1010)	-0.07
Other	0. 1 (53)	0.01	1.0 (123)	0.01
Household Toilet Type				
Flush to sewer system/septic tank/pit latrine/elsewhere	8.7 (463)	0.20	11.2 (1346)	0.22
VIP or latrine with/without slab	72.0 (3836)	-0.01	69.0 (8279)	-0.02
No facility/bush/field	17.7 (945)	-0.13	17.6 (2108)	-0.14
Other	1.6 (86)	-0.03	2.2 (264)	-0.04
Floor Material				
Natural	56.8 (3026)	-0.27	51.3 (6156)	-0.27
Finished	42.9 (2285)	0.27	48.5 (5817)	0.27
Other	0.3 (17)	0.01	0.2 (24)	0.01
External Wall Material				
Natural	42.9 (2284)	-0.22	35.7 (4284)	-0.20
Rudimentary	1.0 (54)	-0.01	0.9 (103)	-0.03
Finished	55.6 (2963)	0.22	62.5 (7496)	0.21
Other	0.5 (29)	<0.01	1.0 (114)	-0.02
Roof Material				
Natural	36.2 (1932)	-0.24	26.3 (3149)	-0.22
Rudimentary	0.2 (9)	-<0.1	0.5 (58)	0.01
Finished	63.6 (3388)	0.24	72.3 (8679)	0.22
Other	0.02 (1)	0.01	0.9 (111)	0.01
Eigenvalue	8.2		7.9	
% variance explained	20.4		20.3	

Footnotes: Five asset variables were excluded from the PCA due to low frequency: one or more grain grinders/hammer mills: 2011/12 0.9 (49) & 2013: 0.9 (106); boat 2011/12: 0.9 (51) & 2013: 0.2 (142); motorcycles 2011/12: 0.7 (38) & 2013: 0.7 (81); tractors 2011/12 0.5 (30) & 2013: 0.6 (67); non-mobile phone 2011/12: 0.9 (52) & 2013: 0.7 (78)

No variables were removed from the PCA as the direction of the weight for all variables was as expected for both surveys (Table 2). The variables assigned the most weight in both surveys were natural and finished flooring (both -0.27 and 0.27, respectively), ownership of televisions (2011/12 survey: 0.25; 2013 survey: 0.26), VCR/DVD players (both 0.25) and fridges (2011/12 survey: 0.23; 2013 survey: 0.25). The eigenvalue of the first principal component were similar (2011/12 survey: 8.2; 2013 survey: 7.9) as was the proportion of the variance in the data explained by the first principal component (both 0.20; Table 2).

Scores were skewed to the right among rural households in both surveys (Figure 1). A higher percent of rural households (2011/12 survey: n=1050, 24%; 2013 survey: n=2363, 24%) were classified as being of lowest SEP compared with urban households (2011/12 survey: n=19, 2%; 2013 survey: n=39, 2%; Table 3). Scores seemed more normally distributed among the few urban households. In the 2011/12 survey, 48% (n=425) of urban households were categorised as being of highest SEP compared with 14% (n=641) of rural households. Results were similar in the 2013 survey with over half (n=1099, 52%) of the urban household classified as highest SEP compared with 13% (n=1299) of rural households.

Figure 1. Histograms of SEP scores by rural and urban status of study sites, 2011/12 & 2013

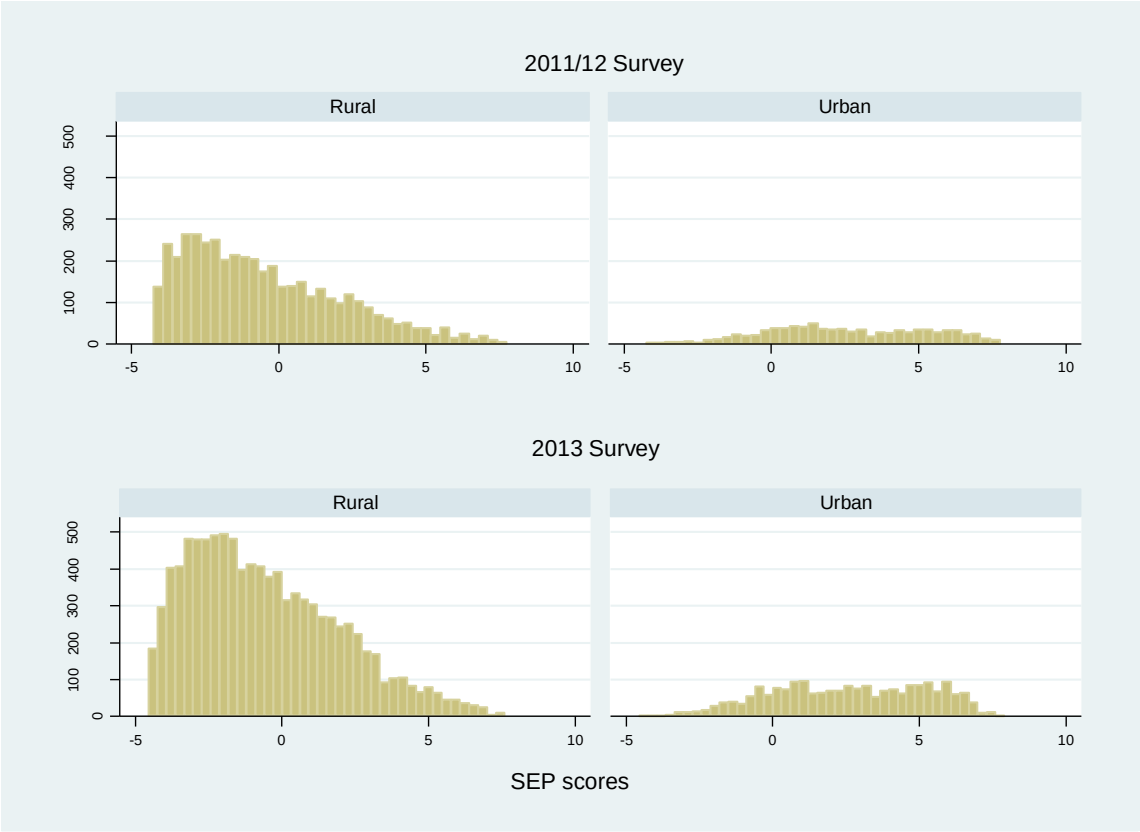


Table 3. Distribution of SEP Groups by Urban/Rural Residence in the 2011/12 and 2013 surveys

	2011/12 (N=5330; n, col %)		2013 (N=11997; n, col %)	
	Rural	Urban	Rural	Urban
Lowest	1050 (23.7)	19 (2.1)	2363 (24.0)	39 (1.8)
Low	1021 (23.0)	42 (4.7)	2258 (22.9)	139 (6.5)
Middle	923 (20.8)	143 (16.1)	2058 (20.9)	342 (16.0)
High	804 (18.1)	262 (29.4)	1887 (19.1)	513 (24.1)
Highest	641 (14.4)	425 (47.7)	1299 (13.2)	1099 (51.6)

Annex 4. Additional Analyses Exploring the Factors Associated with Men's HIV-testing Behaviours

4.1 Factors Associated with Ever-testing, 2013 survey

The factors associated with ever HIV-testing in the 2013 survey were similar to those in the 2011/12 survey (Table 4). Ever-testing was highest among men with complete secondary or higher education (74%) compared to men with no/primary education (58%; adjPR=1.33 95%CI: 1.22-1.45; Table 4). Men in service/professional employment were more likely to have tested for HIV relative to men reporting no employment (78% vs 51%; adjPR=1.17 95%CI: 1.05-1.29)

More than 60% of Protestant men reported ever-testing compared to 50% of men reporting no religion (adjPR= 0.80 95%CI 0.64-0.95;Table 4). Married men were more likely to report ever-testing relative to single men (adjPR=1.20 95%CI: 1.07-1.32). Among married men, ever-testing was higher among men whose spouse reported ever-testing for HIV (77%) relative to men whose spouse never-tested (34%; adjPR=1.96 95%CI 1.34-2.56). Men with a history of TB-treatment were more likely to test for HIV, there was little evidence for an association when HIV-positive men were excluded from analyses (adjPR=1.11 95%CI: 0.92-1.30; p=0.26).

There was strong evidence that levels differed by SEP, with ever-testing higher among men of middle SEP relative to men of lowest SEP (adjPR=1.13 95%CI 1.02-1.24). There was little evidence that the association between SEP and ever-testing was modified by district (p=0.14) or that the prevalence of ever-testing differed by cluster-levels of employment or HIV-prevention knowledge. There was some evidence that ever-testing was lower in clusters with a higher HIV prevalence (Table 4). Ever-testing was higher in clusters where ART was available at the local health facility on the day of the audit (65%) compared with levels in clusters where ART was not available (58%; adjPR=1.15; 95%CI: 1.07-1.24).

Table 4. Distribution of characteristics of men, and factors associated with ever-testing (N=2376), 2013 survey

	Details	Distribution (n, col %)	Ever Tested (n, row %)	Minimally-Adjusted PR (95% CI)	Adjusted PR (95% CI)	p-value[2]
	All Men	2376	1459 (61.4)	-	-	-
Age	15-19	487 (20.5)	159 (32.3)	1.0	1.0	
	20-29	751 (31.6)	492 (65.5)	2.01 (1.73-2.30)	1.98 (1.70-2.26)	<0.01
	30-39	545 (22.9)	408 (74.9)	2.31 (1.98-2.63)	2.29 (1.97-2.61)	(<0.01)
	≥40	593 (25.0)	400 (67.5)	2.07 (1.77-2.37)	2.06 (1.77-2.36)	
Head of Household	No	897 (37.8)	425 (47.4)	1.0	1.0	0.01
	Yes	1479 (62.3)	1034 (69.9)	1.13 (1.03-1.24)	1.13 (1.03-1.24)	
Education	No/Primary	1017 (42.8)	591 (58.1)	1.0	1.0	<0.01
	Incompl secondary	883 (37.2)	517 (58.6)	1.18 (1.09-1.27)	1.17 (1.08-1.26)	(<0.01)
	Secondary/higher	476 (20.0)	351 (73.7)	1.32 (1.22-1.43)	1.33 (1.22-1.45)	
Occupation	None	1093 (46.0)	561 (50.6)	1.0	1.0	0.04
	Agriculture (others land)	534 (22.5)	354 (65.8)	1.06 (0.96-1.16)	1.04 (0.94-1.13)	
	Agriculture (own land)	456 (19.2)	325 (70.5)	1.12 (1.01-1.22)	1.09 (0.98-1.19)	
	Services/professional	293 (12.3)	229 (77.6)	1.25 (1.14-1.37)	1.16 (1.04-1.28)	
Religion	Protestant	909 (38.3)	577 (63.5)	1.0	1.0	0.01
	Catholic	619 (26.1)	390 (63.0)	0.96 (0.89-1.04)	0.97 (0.89-1.04)	
	SDA	357 (15.0)	235 (65.8)	1.04 (0.95-1.13)	1.01 (0.92-1.10)	
	Other	397 (16.7)	235 (52.9)	0.85 (0.77-0.94)	0.87 (0.78-0.95)	
	None	94 (4.0)	47 (50.0)	0.74 (0.58-0.89)	0.80 (0.64-0.95)	
Marital Status	Single	999 (42.0)	477 (47.7)	1.0	1.0	0.02
	Married/cohabiting	1271 (53.5)	910 (71.6)	1.18 (1.06-1.29)	1.16 (1.03-1.28)	
	Ever married	106 (4.5)	72 (67.9)	1.14 (0.95-1.34)	1.17 (0.98-1.37)	
Present continuously past 6mths	No	110 (4.6)	60 (54.6)	1.0	-	-
	Yes	2266 (95.4)	1399 (61.7)	1.11 (0.93-1.29)		

History of TB Treatment	No Yes	2290 (96.4) 86 (3.6)	1391 (60.7) 68 (79.1)	1.0 1.19 (1.03-1.35)	1.0 1.22 (1.06-1.37)	0.01
Household SEP	Lowest Low Middle High Highest	448 (18.9) 453 (19.1) 516 (21.7) 502 (21.1) 457 (19.2)	264 (58.9) 265 (58.5) 337 (65.3) 313 (62.4) 280 (61.3)	1.0 1.05 (0.93-1.17) 1.18 (1.06-1.31) 1.16 (1.03-1.29) 1.19 (1.05-1.33)	1.0 1.03 (0.93-1.14) 1.14 (1.03-1.25) 1.09 (0.97-1.20) 1.02 (0.89-1.16)	0.05
Spouse Characteristics (N=717)						
Currently Pregnant	No Yes	624 (87.0) 93 (13.0)	446 (71.5) 74 (79.6)	1.0 1.11 (0.99-1.24)	1.0 1.09 (0.96-1.21)	0.19
Spouse reports ≥1 Child	No Yes	35 (4.9) 683 (95.1)	21 (60.0) 499 (73.2)	1.0 1.22 (0.88-1.57) 1.24 (0.87-1.60	1.0 1.11 (0.84-1.38)	0.36
Ever HIV-tested	No Yes	7 (9.8) 647 (90.2)	24 (34.3) 496 (76.7)	1.0 2.16 (1.44-2.88)	1.0 1.96 (1.34-2.56)	<0.01
Cluster-level Factors[4]						
>50% of men employed	No Yes	960 (40.4) 1416 (59.6)	581 (60.5) 878 (62.0)	1.0 1.01 (0.92-1.11)	-	-
>25% list 3+ ways to prevent HIV	No Yes	1150 (48.4) 1226 (51.6)	715 (62.2) 744 (60.7)	1.0 0.99 (0.90-1.07)	-	-
HIV Prevalence	<10% >10%	1869 (78.7) 507 (21.3)	1165 (62.3) 294 (58.0)	1.0 0.92 (0.83-1.01)	1.0 0.92 (0.82-1.01)	0.10
HIV Prevalence (self-report)	<10% >10%	1964 (82.7) 412 (17.3)	1198 (61.0) 261 (63.4)	1.0 1.00 (0.88-1.11)	-	-
ART at Local Health Facility1	No Yes	1171 (52.1) 1078 (47.9)	680 (58.1) 697 (64.7)	1.0 1.16 (1.07-1.25)	1.0 1.15 (1.07-1.24)	<0.01

Key: [1] 127 missing (N=2249); [2] For adjusted PR and based on LRT, p-value in brackets is for test assuming linear trend, adjusted based on framework presented in Research Paper III (6)

4.2 Factors Associated with Recent-testing among Ever-testers, 2013 survey

In 2013, 67% (n=701) of ever-testers reported a recent HIV-test. There was little evidence that being a household head, education, marital status, a history of TB-treatment or a period of being absent were associated with a recent HIV-test among ever-testers (Table 5). There was weak evidence that men aged 40+ years were less likely to report a recent HIV-test relative to men aged 15-19 years (adjPR=0.85 95%CI 0.69-1.05). Men reporting employment on other people's land were more likely to report a recent-test relative to men reporting no employment (adjPR=1.36 95%CI 1.16-1.56). Similar to the 2011/12 survey, men reporting no religion were less likely to recently-test relative to Protestant men (36% vs 54%; adjPR=0.64 95%CI: 0.37-0.89). Men whose spouse reported being pregnant at the time of the survey were more likely to report a recent-test (adjPR relative to non-pregnant spouse=1.33 95%CI: 1.02-1.67).

Levels of recent-testing were lower in clusters with lower levels of employment (49% vs 54%) but there was little evidence that these levels differed systematically (p=0.28). There was little evidence that levels of HIV-related prevention knowledge, HIV prevalence of ART availability were associated with recent-testing among ever-testers.

Table 5. Characteristics of ever-testers and factors associated with recent HTC among men with a history of HIV-testing (N=1382), 2013 survey

	Details	Socio-demographics (n, col %)	Recently tested (n, row %)	Minimally-adjusted PR (95%CI)	Adjusted PR (95%CI)	p-value[2]
	All ever-testers	1382	701 (66.7)	-	-	-
Age	15-19	157 (11.4)	86 (54.8)	1.0	1.0	0.13
	20-29	490 (35.5)	265 (54.1)	1.00 (0.83-1.17)	1.00 (0.83-1.18)	
	30-39	388 (28.1)	192 (49.5)	0.91 (0.75-1.09)	0.93 (0.76-1.10)	
	≥40	347 (25.1)	158 (45.5)	0.83 (0.67-0.99)	0.85 (0.69-1.02)	
Household Head	No	417 (30.2)	222 (53.2)	1.0	-	-
	Yes	965 (69.8)	481 (49.8)	1.01 (0.87-1.16)		
Education	No Education	547 (39.6)	274 (50.1)	1.0	-	-
	Primary	499 (36.1)	265 (53.1)	1.01 (0.89-1.14)		
	Secondary or higher	336 (24.3)	162 (48.2)	0.95 (0.81-1.10)		
Occupation	None	535 (38.7)	251 (46.9)	1.0	1.0	<0.01
	Agriculture	328 (23.7)	184 (56.1)	1.34 (1.14-1.54)	1.36 (1.16-1.56)	
	Agriculture (own land)	304 (22.0)	157 (51.6)	1.22 (1.02-1.42)	1.20 (1.00-1.41)	
	Services/professional	215 (15.6)	109 (50.7)	1.19 (0.98-1.40)	1.20 (1.00-1.41)	
Religion	Protestant	547 (39.6)	293 (53.6)	1.0	1.0	0.01
	Catholic	367 (26.6)	192 (52.3)	0.94 (0.82-1.07)	0.96 (0.84-1.09)	
	SDA	224 (16.2)	116 (51.8)	0.93 (0.78-1.08)	0.93 (0.77-1.07)	
	Other	197 (14.3)	83 (42.1)	0.77 (0.62-0.92)	0.77 (0.63-0.92)	
	None	47 (3.4)	17 (36.2)	0.64 (0.38-0.91)	0.64 (0.37-0.89)	
Marital Status	Single	470 (34.0)	255 (54.3)	1.0	-	-
	Married/cohabiting	846 (61.2)	413 (48.8)	0.97 (0.82-1.12)		
	Ever married	66 (4.8)	33 (50.0)	1.02 (0.74-1.30)		
History of TB Treatment	No	1335 (96.6)	675 (50.6)	1.0	-	-
	Yes	47 (3.4)	26 (55.3)	1.10 (0.81-1.39)		

Present continuously previous 6mth	No Yes	59 (4.3) 1323 (95.7)	34 (57.6) 669 (50.5)	1.0 0.88 (0.67-1.09)	-	-
SEP Group	Lowest Low Middle High Highest	252 (18.5) 239 (17.6) 312 (23.0) 291 (21.4) 265 (19.5)	123 (47.9) 121 (49.2) 166 (52.2) 156 (53.2) 135 (50.4)	1.0 1.04 (0.84-1.24) 1.14 (0.93-1.34) 1.16 (0.95-1.38) 1.14 (0.91-1.37)	-	-
Spouse ever HIV-tested	No Yes	19 (4.0) 453 (96.0)	8 (42.1) 212 (46.8)	1.0 1.00 (0.47-1.53)	-	-
Spouse currently pregnant	No Yes	402 (85.2) 70 (14.8)	179 (44.5) 41 (58.6)	1.0 1.38 (1.07-1.71)	1.0 1.33 (1.02-1.67)	0.02
Spouse reports having 1+ children	No Yes	16 (3.4) 456 (96.6)	247 (54.2) 209 (45.8)	1.0 0.77 (0.45-1.10)	-	-
>50% of men employed	No Yes	558 (40.4) 824 (59.6)	300 (53.8) 401 (48.7)	1.0 0.88 (0.73-1.03)	1.0 0.88 (0.73-1.03)	0.28
>25% of men name 3+ ways to prevent HIV	No Yes	865 (62.6) 517 (37.4)	433 (50.1) 268 (51.8)	1.0 1.02 (0.85-1.19)	-	-
HIV Prevalence	<10% >10%	1112 (80.5) 270 (19.5)	574 (51.6) 127 (47.0)	1.0 0.95 (0.76-1.14)	-	-
ART at Local Health Facility[1]	No Yes	640 (49.1) 663 (50.9)	335 (52.3) 326 (49.2)	1.0 0.96 (0.81-1.10)	-	-

Key: Excludes men missing data on dates of first and last HIV-test (n=8) and men tested HIV-positive >1 year preceding the survey (n=69); [1] 79 missing data because audit missing for 2 facilities; [2] p-value for adjusted PR from LRT

4.3 Acceptance of an Offer of Home-Based HIV-testing among Never-Testers, 2011/12 and 2013 surveys

In the 2011/12 survey, 53% (n=699) of never-testers, with no missing data on variables of interest accepted the offer of home-based HIV-testing (Table 6). Some 6% (n=43) tested HIV-positive. Men aged 40+ years were less likely to accept the offer relative to men aged 15-19 years. There was no evidence that education, religion, marital status or a history of TB-treatment were associated with acceptance. There was weak evidence that SEP was associated, with men of highest SEP less likely to accept the offer relative to men of lowest SEP (40% vs 61%, respectively; adjPR=0.85 95%CI: 0.67-1.03). District was strongly associated with acceptance of the offer, with acceptance higher in Luangwa relative to Kafue (61% vs. 35%).

In the 2013 survey, 48% (n=439) of never-testers accepted the offer of home-based HIV-testing (Table 7). Some 5% (n=21) tested HIV-positive; 38% (n=21/56) of all men testing HIV-positive at this test. There was weak evidence that men with a spouse who was pregnant at the time of the survey were less likely to accept home-based HIV-testing (adjPR=0.61 95%CI: 0.17-1.06). There was strong evidence that acceptance was lower in clusters where cluster-level employment was higher (adjPR=0.82 95%CI: 0.64-1.00). There was little evidence that acceptance differed in clusters with higher levels of HIV-prevention knowledge or HIV-prevalence, or by whether ART was available at the health facility on the day of the audit.

Table 6. Acceptance of home-based HIV-testing by socio-demographic characteristics and factors associated with acceptance among men with no history of HIV-testing (N=1320), 2011/12 survey

	Details	Distribution (n, col %)	HBHTC (n, row %)	Age-adjusted PR (95%CI)	Adjusted PR (95%CI)	p-value[3]
	All Men	1320	699 (53.0%)	-	-	-
Age[1]	15-19	427 (32.3)	229 (53.6)	1.0	1.0	0.03
	20-29	330 (25.0)	187 (56.7)	1.12 (0.96-1.28)	1.11 (0.97-1.25)	
	30-39	250 (18.9)	135 (54.0)	1.04 (0.88-1.21)	1.04 (0.89-1.19)	
	≥40	313 (23.7)	148 (47.3)	0.89 (0.75-1.04)	0.89 (0.76-1.03)	
Education[2]	No Education	52 (3.9)	27 (51.9)	1.0	1.0	0.42
	Primary	576 (43.6)	325 (56.4)	1.09 (0.77-1.41)	1.08 (0.79-1.38)	
	Secondary or higher	692 (52.4)	347 (50.1)	0.96 (0.68-1.25)	1.01 (0.73-1.29)	
Religion[3]	Protestant	460 (34.8)	248 (53.9)	1.0	-	-
	Catholic	353 (26.7)	196 (55.5)	0.99 (0.85-1.12)		
	SDA	150 (11.4)	72 (48.0)	0.87 (0.70-1.05)		
	Other	302 (22.9)	157 (52.0)	0.90 (0.76-1.04)		
	None	55 (4.2)	26 (47.3)	0.76 (0.49-1.02)		
Marital Status	Single	706 (53.5	391 (55.4)	1.0	-	-
	Married/cohabiting	546 (41.4	273 (50.0)	0.88 (0.73-1.04)		
	Ever married	68 (5.1)	35 (51.5)	0.95 (0.68-1.23)		
History of TB Treatment[4]	No	1301 (98.6)	691 (53.1)	1.0	-	-
	Yes	19 (1.4)	8 (42.1)	0.87 (0.42-1.31)		
SEP Group[5]	Lowest	223 (16.9)	135 (60.5)	1.0	1.0	0.15
	Low	276 (20.9)	159 (57.6)	0.95 (0.79-1.11)	0.98 (0.82-1.15)	
	Middle	265 (20.1)	138 (52.1)	0.87 (0.71-1.02)	0.92 (0.76-1.08)	
	High	289 (21.9)	161 (55.7)	0.98 (0.81-1.14)	1.05 (0.88-1.22)	
	Highest	267 (20.2)	106 (39.7)	0.74 (0.57-0.90)	0.85 (0.67-1.03)	
Spouse ever HIV-tested	No	92 (29.7)	43 (46.7)	1.0	-	-
	Yes	218 (70.3)	113 (51.8)	1.12 (0.81-1.44)		
Spouse currently pregnant	No	271 (87.4)	133 (49.1)	1.0	-	-
	Yes	39 (12.6)	23 (59.0)	1.22 (0.84-1.60)		

Spouse reports having 1+ children	No Yes	17 (5.5) 293 (94.5)	8 (47.1) 150 (50.9)	1.0 1.13 (0.48-1.79)	-	-
HIV Prevalence	<10% >10%	1018 (77.1) 302 (22.9)	517 (50.8) 182 (60.3)	1.0 1.16 (0.87-1.44)	-	-
ART at Local Health Facility	No Yes	999 (75.7) 321 (24.3)	544 (54.5) 155 (48.3)	1.0 0.90 (0.65-1.14)	-	-
District	Kafue Chongwe Luangwa	423 (32.0) 752 (57.0) 145 (11.0)	147 (34.8) 464 (61.7) 88 (60.7)	1.0 1.82 (1.41-2.24) 1.82 (1.31-2.32)	1.0 1.82 (1.41-2.24) 1.82 (1.31-2.32)	<0.01

Key: Among never-testers, 28 were missing data on variables of interest and removed from analyses, including[1] 2 missing data; [2] 1 missing data; 3 16 missing data; [4] 1 missing data; [5] 4 missing data

Table 7. Acceptance of home-based HIV-testing by socio-demographic characteristics and factors associated with acceptance among men with no history of HIV-testing (N=917), 2013 survey

	Details	Distribution (n, col %)	HBHTC (n, row %)	Minimally-adjusted PR (95%CI)	Adjusted PR (95%CI)	p-value[3]
	All Men	917	439 (47.9%)	-	-	-
Age	15-19	328 (35.8)	168 (51.2)	1.0	-	-
	20-29	259 (28.2)	129 (49.8)	0.97 (0.80-1.14)		
	30-39	137 (14.9)	56 (40.9)	0.85 (0.65-1.04)		
	≥40	193 (21.0)	86 (44.6)	0.91 (0.73-1.09)		
Household Head	No	472 (51.5)	239 (50.6)	1.0	-	-
	Yes	445 (48.5)	200 (44.9)	0.95 (0.76-1.14)		
Education	None/Primary	426 (46.5)	210 (49.3)	1.0	1.0	0.36
	Secondary	366 (39.9)	180 (49.2)	0.96 (0.81-1.11)	0.98 (0.83-1.14)	
	Compl secondary/higher	125 (13.6)	49 (39.2)	0.76 (0.56-0.95)	0.83 (0.61-1.06)	
Occupation	None	536 (58.5)	272 (50.8)	1.0	1.0	0.30
	Agriculture	182 (19.9)	93 (51.1)	1.10 (0.90-1.31)	1.12 (0.91-1.34)	
	Agriculture (own land)	134 (14.6)	50 (37.3)	0.85 (0.63-1.07)	0.89 (0.67-1.12)	
	Services/professional	65 (7.1)	24 (36.9)	0.78 (0.50-1.06)	0.89 (0.59-1.19)	
Religion	Protestant	332 (36.2)	149 (44.9)	1.0	1.0	0.18
	Catholic	229 (25.0)	106 (46.3)	0.95 (0.76-1.14)	0.95 (0.77-1.13)	
	SDA	122 (13.3)	55 (45.1)	0.99 (0.76-1.22)	0.99 (0.76-1.22)	
	Other	187 (20.4)	107 (57.2)	1.22 (1.00-1.45)	1.20 (0.98-1.42)	
	None	47 (5.1)	22 (46.8)	0.94 (0.60-1.28)	0.89 (0.57-1.22)	
Marital Status	Single	522 (56.9)	258 (49.4)	1.0	-	-
	Married/cohabiting	361 (39.4)	166 (46.0)	1.12 (0.88-1.36)		
	Ever married	34 (3.7)	15 (44.1)	1.10 (0.64-1.55)		
History of TB Treatment	No	899 (98.0)	428 (47.6)	1.0	1.0	0.19
	Yes	18 (2.0)	11 (61.1)	1.37 (0.87-1.86)	1.33 (0.85-1.82)	

Present continuously in previous 6mths	No	50 (5.5)	25 (50.0)	1.0	-	-
	Yes	867 (94.6)	414 (47.8)	0.92 (0.65-1.19)		
SEP Group	Lowest	184 (20.1)	90 (48.9)	1.0	1.0	0.19
	Low	188 (20.5)	87 (46.3)	1.01 (0.78-1.24)	1.02 (0.79-1.26)	
	Middle	179 (19.5)	102 (57.0)	1.22 (0.95-1.49)	1.24 (0.97-1.51)	
	High	189 (20.6)	84 (44.4)	0.97 (0.74-1.20)	1.00 (0.76-1.24)	
	Highest	177 (19.3)	76 (42.9)	0.89 (0.65-1.14)	1.00 (0.74-1.27)	
Spouse Characteristics (N=197)						
Spouse ever HIV-tested	No	46 (23.4)	18 (39.1)	1.0	-	-
	Yes	151 (76.7)	76 (50.3)	1.25 (0.74-1.76)		
Spouse currently pregnant	No	178 (90.4)	88 (49.4)	1.0	1.0	0.12
	Yes	19 (9.6)	6 (31.6)	0.58 (0.16-1.00)	0.61 (0.17-1.06)	
Spouse reports having 1+ children	No	14 (7.1)	4 (28.6)	0.56 (0.08-1.05)	0.62 (0.12-1.13)	0.18
	Yes	183 (92.9)	90 (49.2)	1.0	1.0	
Cluster-level Characteristics						
>50% of men employed	No	379 (41.3)	211 (55.7)	1.0	1.0	0.08
	Yes	538 (58.7)	228 (42.4)	0.79 (0.63-0.95)	0.82 (0.64-1.00)	
>25% of men name 3+ ways to prevent HIV	No	435 (47.4)	186 (42.8)	1.0	1.0	0.58
	Yes	482 (52.6)	253 (52.5)	1.24 (0.98-1.50)	1.05 (0.83-1.28)	
HIV Prevalence	<10%	704 (76.8)	339 (48.2)	1.0	-	-
	>10%	213 (23.2)	100 (46.9)	1.01 (0.76-1.25)		
ART at Local Health Facility[1]	No	491 (56.3)	230 (46.8)	1.0	-	-
	Yes	381 (43.7)	188 (49.3)	1.03 (0.81-1.24)		

Key: [1] 45 missing data [2] For adjusted PR and based on LRT

Annex 5. Heckman-type Selection Modelling

Participating men differed from non-participating men. Outcomes were at risk of bias. I used Heckman-type selection models to explore whether there was any evidence for unobserved factors associated with participation and HIV-testing that would bias observed outcomes (7). Heckman-type selection models are used to explore whether outcomes can be considered "missing at random" (MAR) conditional on the data available for non-participants. The models include a selection variable that is associated with participation but not causally related to the outcome of interest. I identified three plausible selection variables that were likely to be causally related to participation in a survey but unlikely to be causally related to the HIV-testing outcomes of interest, namely time of the survey, day of the survey and season of the survey.

I explored whether the selection variables were independently associated with participation as hypothesised using random effects logistic regression to control for clustering by study site.

I ran the models in two steps:

> Model 1: Participation + selection variable
>
> Model 2: Model 2 + selection variables and variables on non-participations associated with participation at the $p<1.0$ level

In Model 1 I explored whether there was a crude association between each selection variable and participation. In Model 2, I included variables available on non-participants that were associated at the $p<0.1$ level in crude models to determine whether the selection variables were independently associated with participation. Where there was evidence of multicollinearity I removed one of the variables, as seen with head of household and age category, including only the variable that was the strongest predictor of participation.

I used the *heckprob* command in Stata 13.0 in which I included factors known or theorised *a priori* to be associated with HIV-testing and available for non-participants in the outcomes model and variables associated with participation in the selection model. I included a cluster identifier to control for clustering. Models were run on enumerated men with complete data.

I conducted Heckman-type selection modelling for ever-testing for both surveys and for the main outcome for each Research Paper. In Research Paper IV, I presented findings of the Heckman-type selection modelling for ever- and multiple HIV-testing in 2013, including the association between selection variables and participation, the distribution of characteristics of men by the selection variables and the rho (95%CI) for the association between unobserved factors between participation and the outcomes (6). I present the predicted outcomes among non-participants in Table 9, alongside observed estimates and estimates adjusted for the predicted prevalence among non-participants. I present the rho and its 95%CI.

5.1 Identifying Selection Variables for Heckman-Type Selection Models

In 2011/12, men visited in the late afternoon were less likely to participate relative to men visited in the morning (41% vs 44, respectively; adjPR=0.83 95%CI 0.71-0.96; Table 8). There was weak evidence that day of the survey was associated with participation and little evidence that season was associated. Results for the 2013 survey were presented in Research Paper III (Chapter 8; (6)). For the 2011/12 survey, time of the survey was considered a strong selection variable.

In 2011/12, there was little evidence for any unobserved factors associated with ever-testing and participation (rho=-0.02 95%CI: -0.90 to 0.90; Table 9). Adjusting prevalence of ever-testing for the predicted prevalence among non-participants, the adjusted prevalence was 51.5%. In the 2013 survey, the adjusted estimate of the prevalence of ever-testing for HIV was 64.6%. Results were similar when day of the survey was included as a selection variable.

Table 8. Distribution of enumerated men by research processes and the association between research processed and participation in the 2011/12 survey (N=6295)

	Description	Distribution (n, col %)	Participants (n, row %)	Crude PR (95%CI)	Adjusted PR (95%CI)[1]	p-value
Time of Survey	Morning (630-12)	3259 (51.8)	1427 (43.8)	1.0	1.0	<0.01
	Afternoon (12-16)	2709 (43.0)	1246 (46.0)	1.05 (0.99-1.11)	1.04 (0.98-1.09)	
	Late pm (16-1830)	327 (5.2)	133 (40.7)	0.86 (0.74-0.99)	0.83 (0.71-0.96)	
Day of Survey	Mon-Thurs	4640 (73.7)	2010 (43.3)	1.0	1.0	0.15
	Friday	1137 (18.1)	547 (48.1)	1.10 (1.02-1.17)	1.07 (1.00-1.14)	
	Sat-Sunday	518 (8.2)	249 (48.1)	1.08 (0.96-1.19)	1.03 (0.92-1.14)	
Season of Survey	Rainy (Dec-Apr)	1535 (24.4)	719 (46.8)	1.0	1.0	0.61
	Cool/dry(May-Aug)	2722 (43.2)	1168 (42.9)	0.92 (0.79-1.04)	0.95 (0.85-1.05)	
	Hot (Sept-Nov)	2038 (32.4)	919 (45.1)	0.97 (0.84-1.09)	0.99 (0.88-1.10)	

Key: [1] Adjusted for whether household head, present all months in the previous 6, SEP, household size, urban residence and district

Table 9. Observed Ever-testing for HIV and ever-testing as predicted by Heckman and adjusted based on Heckman results, 2011/12 and 2013 survey, with recent- and multiple-testing also estimated for 2013 survey

	Mean %	95%CI	Rho (95%CI) Heckman only	p-value
Ever HIV-testing 2011/12 Survey				
Observed (N=2802) [1]	52.2	48.5-56.0		
Predicted among non-participants (Heckman; N=3490)	51.0	48.7-53.1	-0.02 (-0.90 to 0.90)	0.98
Adjusted after Heckman (N=6291)	51.5	48.9-54.1		
Ever HIV-testing 2013 Survey				
Observed (N=2436) [2]	61.5	58.6-64.4		
Predicted among non-participants (Heckman; N=3334)	65.5	64.2-66.7	-0.12 (-0.93 to 0.88)	0.88
Adjusted after Heckman (N=5770)	64.6	63.2-66.0		
Multiple HIV-testing 2013 Survey				
Observed (N=2428) [3]	35.5	32.2-38.9		
Predicted among non-participants (Heckman; N=3334)	29.0	27.5-31.0	0.20 (-0.87 to 0.94)	0.88
Adjusted after Heckman (N=5762)	31.8	30.2-33.3		
Recent HIV-testing 2013 Survey				
Observed (N=2428) [4]	30.0	27.1-32.9		
Predicted among non-participants (Heckman; N=3334)	27.2	26.7-27.8	0.02 (-0.75 to 0.77)	0.96
Adjusted after Heckman (N=5762)	28.5	27.1-29.7		

Key: [1] Excludes 4 men missing data on HIV-testing outcome; [2] Excludes 27 men with missing data on HIV-testing outcome & 5 men missing SEP data; [3] 8 men missing data on year of first and last test excluded; [4] Includes men who reported knowing their HIV-positive status more than one year before the survey

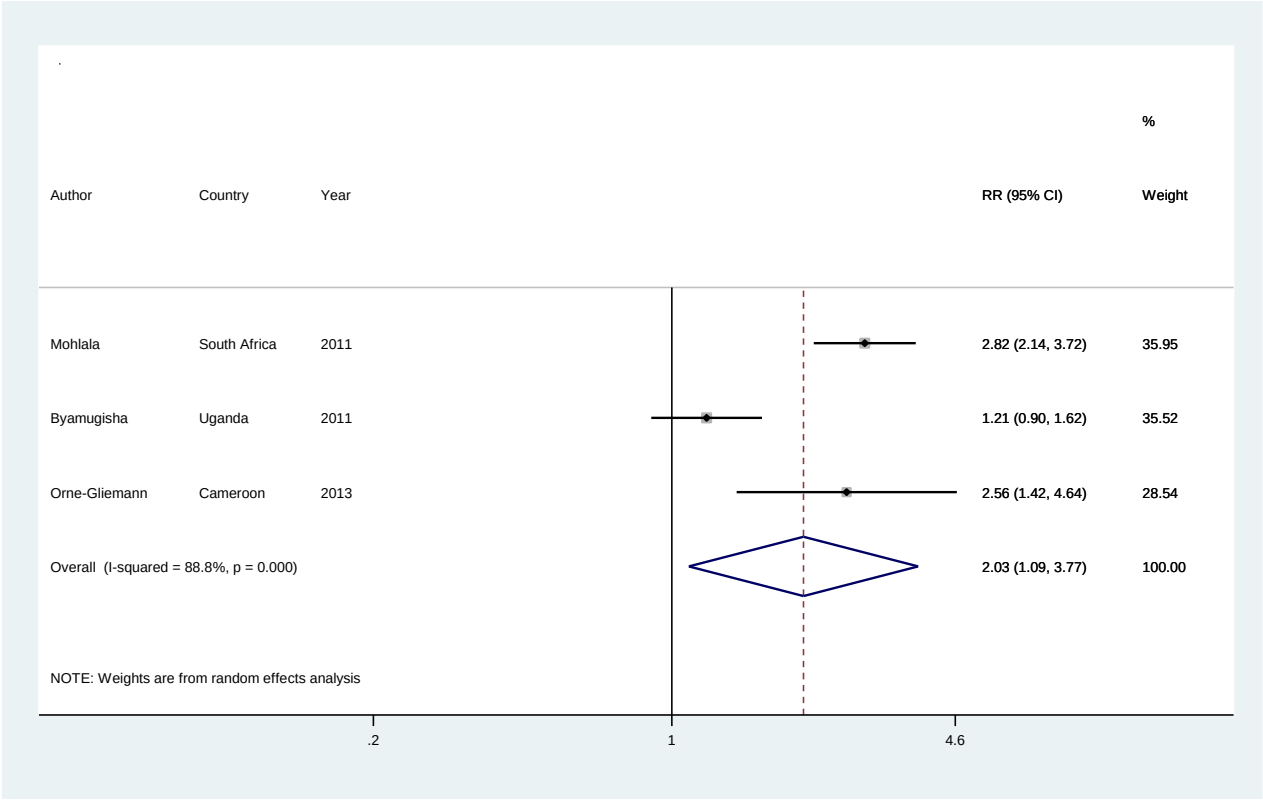
Annex 6. Meta-analysis of Three Trials Included in Research Paper I

Three of the trials included in the systematic review aimed to provide men with facility-based services by reaching them through their pregnant partners (8-10). As the strategies to reach men appeared similar across these trials I decided to conduct a meta-analysis to obtain a summary measure of effect across these trials.

A random effects meta-analysis was run in Stata 13.0 using the *metan* command with *random*. I opted for a random as opposed to fixed effects meta-analysis as I expected that the true effect would differ across the trials due to differences in the trial settings, type of intervention, delivery of the intervention among other differences across the trials (11).

Overall, the trials aimed to reach 2544 men: 1269 in intervention and 1275 in control arms. The pooled proportion of men testing in intervention arms was 22% (95% CI: 20%-24%) compared with 11% (95% CI: 9%-13%) in control arms (Figure 2). The pooled risk ratio was 2.0 (95% CI: 1.1-3.8). The trials conducted in South Africa and Uganda contributed roughly equally to the pooled summary estimate whereas the trial conducted in Cameroon contributed the least (roughly 36% vs 29%, respectively). There was strong evidence against the null of no heterogeneity across the trials (Q^2=17.8; $p<0.01$).

Figure 2. Forest plot of a random effects meta-analysis of three trials to reach men with facility-based HTC through their pregnant partners



Although the South African and Ugandan trial both evaluated the effect of an invitation to male partners and were considered more similar than the trial conducted in Cameroon, their confidence intervals did not overlap suggesting that the true effect underlying these trials were heterogeneous (12). The p-value of the Q^2 estimate suggested evidence against the null hypothesis of no heterogeneity. Furthermore, the I^2 estimate, which describes inconsistency across the trials (13), highlights that roughly 89% of the variability in the estimates of effect are due to differences across the trials as opposed to chance (12).

Considering the results of this meta-analysis, the decision was made not to conduct meta-analyses of the other trials as the interventions and populations they targeted were more diverse relative to these trials. Furthermore, the decision was made not to include the meta-analysis in the final manuscript.

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