Increasing men's uptake of HIV-testing in sub-Saharan Africa: a systematic review of interventions and analyses of population-based data from rural Zambia

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Declaration

I, Bernadette Hensen, declare that this thesis is my own work, and that I have acknowledged all results and quotations from the published or unpublished work of other people. I have exercised reasonable care to ensure that the work is original and does not to the best of my knowledge break any UK law or infringe any third party's copyright or other intellectual property right.

Abstract

Men's uptake of HIV-testing and counselling services across sub-Saharan Africa is inadequate relative to universal access targets. A better understanding of the effectiveness of available interventions to increase men's HIV-testing and of men's HIV-testing behaviours is required to inform the development of strategies to increase men's levels and frequency of HIV-testing.

My thesis aims to fill this gap. To achieve this, I combine a systematic review of randomised trials of interventions to increase men's uptake of HIV-testing in sub-Saharan Africa with analyses of two population-based surveys from Zambia, through which I investigate the levels of and factors associated with HIV-testing behaviours. I also conduct an integrated analyses to explore whether the scale-up of voluntary medical male circumcision (VMMC) services between 2009 and 2013 contributed to increasing men's population levels of HIV-testing.

In the systematic review I find that strategies to increase men's HIV-testing are available. Health facility-based strategies, including reaching men through their pregnant partners, reach a high proportion of men attending facilities, however, they have a low reach overall. Community-based mobile HIV-testing is effective at reaching a high proportion of men, reaching 44% of men in Tanzania and 53% in Zimbabwe compared to 9% and 5% in clinic-based communities, respectively. In the population-based surveys, HIV-testing increased with time: 52% of men ever-tested in 2011/12 compared to 61% in 2013. Less than one-third of men reported a recent-test in both surveys and 35% multiple lifetime HIV-tests. Having a spouse who ever-tested and markers of socioeconomic position were associated with HIV-testing outcomes and a history of TB with ever-testing. The scale-up of VMMC provided men who opt for circumcision with access to HIV-testing services: 86% of circumcised men ever-tested for HIV compared to 59% of uncircumcised men. However, there was little evidence that VMMC services contributed to increasing HIV-testing among men in this rural Zambian setting.

Existing strategies to increase men's uptake of HIV-testing are effective. Over half the men in two population-based surveys reported ever-testing for HIV in rural Zambia. Nonetheless, some 40% of men never-tested. Men's frequency of HIV-testing was low relative to recommendations that individuals with continued risk of HIV-infection retest annually for HIV. Innovative strategies are

required to provide never-testers with access to available services and to increase men's frequency of HIV-testing.

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List of Acronyms

AIDS	Acquired immune deficiency syndrome
AIS	AIDS Indicator Survey
ANC	Antenatal care
ART	Anti-retroviral therapy
ARV	Anti-retroviral viral
BHOMA	Better health outcomes through mentoring and assessment
CHAZ	Churches Health Association of Zambia
CHTC	Couples HIV testing and counselling
CHW	Community healthcare worker
CIDRZ	Centre for Infectious Disease Research in Zambia
CRT	Cluster randomised trial
CSO	Central Statistics Office
DHS	Demographic and Health Surveys
HIV	Human immunodeficiency virus
HTC	HIV testing and counselling
IQR	Inter-quartile range
MAR	Missing at random
MSI	Marie Stopes International
NASF	National AIDS Strategic Framework
OR	Odds ratio
PCA	Principal component analysis
PD	Prevalence difference
PDA	Personal digital assistant
PITC	Provider initiated testing and counselling
PMTCT	Prevention of mother to child transmission
PR	Prevalence ratio
RA	Research assistant
RCT	Randomised controlled trial

RR	Relative risk
SEP	Socioeconomic position
SFH	Society for Family Health
STI	Sexually transmitted infection
TB	Tuberculosis
UNAIDS	Joint United Nations Programme on HIV/AIDS
UTT	Universal test and treat
VCT	Voluntary counselling and testing
VMMC	Voluntary medical male circumcision
WHO	World Health Organization
ZNS	Zambian National Services

Section 1: Introduction and Background

Chapter 1. Introduction

Over the past decade, progress has been made in global efforts to reduce the incidence of human immunodeficiency virus (HIV) infection and in providing individuals living with HIV access to anti-retroviral therapy (ART) treatment (1). The Joint United Nations Programme on HIV/AIDS (UNAIDS) reported 2.1 million new infections in 2013, a 38% decline since 2001 (2). In sub-Saharan Africa, where 71% of individuals living with HIV reside, 60% of individuals eligible for ART under the World Health Organization (WHO) 2010 treatment guidelines were receiving treatment (3). Despite progress, some 45% of individuals living with HIV remain unaware of their HIV-status (3). These individuals are at risk of transmitting HIV to their sexual partners and of experiencing higher morbidity and mortality if initiated on ART at late stages of immune suppression (4).

As the first step in the HIV care cascade and in linkage to HIV prevention services, HIV-testing and counselling (HTC) is key to decreasing morbidity and mortality among individuals living with HIV and to the prevention and control of the HIV epidemic (5). The progress over the last decade in increasing knowledge of HIV-status among individuals in sub-Saharan Africa is, in part, attributable to the increased availability of standalone voluntary counselling and testing (VCT) sites and the implementation of provider-initiated testing (PITC) in health facilities (1, 6, 7).

The scale-up of these HTC services was driven by evidence that, despite increased ART availability, few individuals living with HIV in low- and middle-income countries were accessing treatment despite being eligible (8, 9). A barrier to accessing ART was found to be low knowledge of HIV status (10). Furthermore, opportunities to diagnose HIV-positive individuals in health facility settings were being missed (11).

Evidence of the efficacy of ART emerged in the context of prevention of mother to child transmission (PMTCT) (6, 12). PITC was therefore implemented in antenatal care (ANC) settings (6, 7, 10). As such, PITC has increased women's HIV-testing, with HIV-testing nearly universal among pregnant women in ANC in various countries (6, 13). Conversely, men's levels of HIV-testing remain inadequate (14). Available evidence reveals disparities in self-reported HIV-testing between men and women (1, 15).

Men are less likely than women to access healthcare services (16, 17). Barriers to access include logistical, social and economic barriers (18). Strategies are needed that reach men who have never-tested for HIV and encourage men with an ongoing risk of HIV-infection to retest for HIV annually. There is limited systematic evidence of the strategies that are effective at increasing men's HIV-testing (19). Furthermore, whether these alternate strategies have increased men's population-levels of HIV-testing warrants investigation.

Voluntary medical male circumcision (VMMC) services are being scaled-up in 14 priority countries in sub-Saharan Africa, including Zambia (20-22). VMMC is a community-based combination HIV-prevention intervention, with men offered PITC and condoms prior to circumcision (23). Through the offer of PITC, the scale-up of VMMC services is likely to have a direct effect on men's population-levels of ever-testing for HIV (24, 25). The scale-up of services may also have indirect effects on HIV-testing through normalising knowing ones HIV-status, encouraging men not opting for circumcision to access HTC services and increasing the lifetime frequency of HIV-testing among circumcised men.

Through four research papers and linking chapters, I provide evidence of the strategies effective at increasing men's HIV-testing and, with a focus on Zambia, the levels of and factors associated with men's HIV-testing in the context of the expanded availability and promotion of HTC. To achieve this, I combine a systematic review (19) with analyses of population-based surveys of a rural population of Zambian men (14, 26), and an integrated analysis of survey and programmatic data to explore whether VMMC services have contributed to increasing men's population-levels of HIV-testing. Evidence emerging form the research papers is synthesised to develop recommendations for a combination of strategies to increase HIV-testing among Zambian men alongside recommendations for future research.

Chapter 2. Background

In this chapter I provide a brief history of the response to delivering HTC services and highlight the growing gender gap in the uptake of HIV-testing. I provide a summary of current strategies to increase population-levels of HIV-testing, with a focus on men, and include Research Paper I, a systematic review of strategies to increase men's HIV-testing in sub-Saharan Africa (19).

2.1 The response to delivering HIV-testing and counselling services

In developed countries, the first HIV antibody tests were available in the mid-1980s, prior to the availability of treatment (7, 10). In the absence of treatment, testing individuals for HIV-infection was a subject of debate that centred on the ethics and psychological consequences of diagnostic testing (7, 10, 27). Emphasis instead was placed on counselling individuals suspected to be living with HIV (7, 9, 10). It is within this backdrop that the initial approach to delivering HTC services was developed (7, 9, 10). Termed VCT, the delivery of services was client-initiated, emphasised confidentiality, pre- and post- test counselling and voluntary informed written consent (7, 10).

In the mid-1990s, evidence that ART could reduce by two-thirds mother to child transmission of HIV (12) and the mortality and morbidity associated with HIV-infection surfaced (7, 10). This transformed the role of HIV-testing from a diagnostic tool offering little benefit to a "gateway" to life-saving treatment (10, 28, 29). The consensus among public health experts and clinicians was that HIV-testing of individuals symptomatic of HIV-infection should be standard clinical practice (7, 30).

In 2003, an estimated 1% of people in need of ART were accessing treatment, the majority of whom resided in high-income countries (7, 31). The WHO declared this failure to provide access to essential medicines a global health emergency (7, 31, 32), giving rise to a number of initiatives to expand ART availability, including the 3-by-5 initiative (32-34). Nonetheless, access to ART remained low throughout the early 2000s (7). Between 2005 and 2007, a median of less than 20% of people living with HIV were aware of their HIV status (35). Evidence emerged of missed opportunities to diagnose patients attending health facilities and of the limitations of relying on VCT as the only strategy for delivering HTC services (9-11, 30, 31, 36, 37).

In response, various countries, including Botswana in 2004 and Zambia in 2006, adopted PITC policies (5, 7, 38, 39). In 2007, WHO launched guidance on PITC in health facilities and in subsequent years various African countries developed national PITC policies (7, 8). PITC integrates HTC into routine clinical practice, placing the responsibility of offering HTC services on the provider (7, 8). It removes pre-test counselling, with individuals offered pre-test information, but maintains post-test counselling (8). Rather than written informed consent, patients are offered the opportunity to opt-out of HIV-testing (8). PITC aims to normalise testing for HIV and remove barriers associated with requesting an HIV-test, including concerns that healthcare providers may stigmatise patients requesting an HIV-test (6, 8, 40).

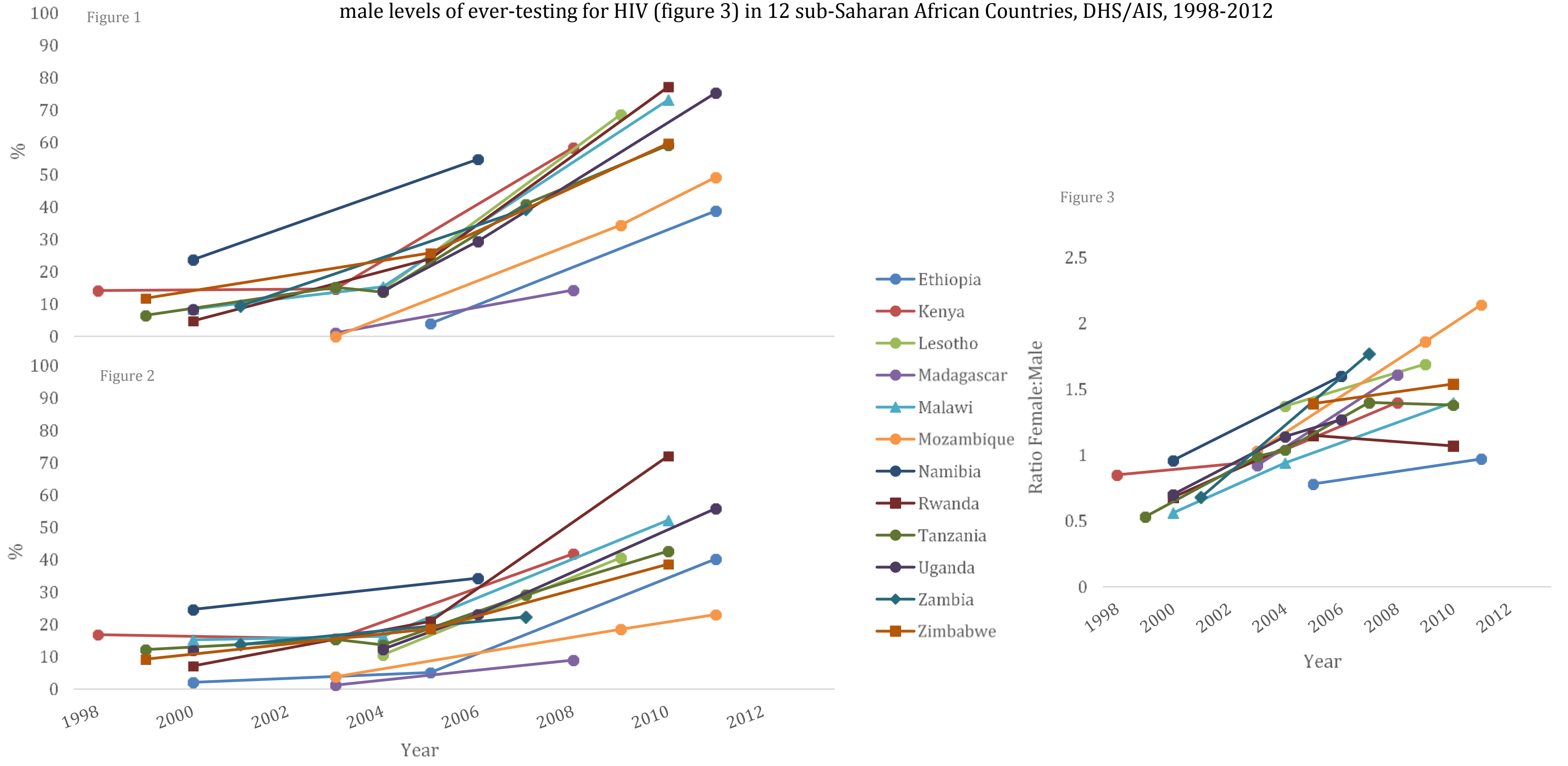
PITC was implemented in ANC in support of PMTCT (10) and recommended for patients symptomatic of acquired immune deficiency syndrome (AIDS) and in TB clinics (8, 10). For high prevalence countries, WHO recommended that PITC be implemented in all health care settings (8). In the context of ART availability and the development of rapid HIV-tests, the response to delivering HIV-testing services was evolving rapidly (7, 9, 30) with HIV-testing now viewed as key to the prevention and control of the HIV epidemic (31, 41).

2.2 The gender gap in HIV-testing

Prior to the implementation of PITC in ANC, there were concerns that men would be more likely to access HTC and ART compared to women (42, 43). Demographic and Health Survey (DHS) and AIDS Indicator Survey (AIS) data from 12 sub-Saharan African countries, including Kenya, Zambia and Zimbabwe, highlight that prior, to 2004, the prevalence of ever-testing for HIV was <25% (44, 45). During this period, men's levels of ever-testing were higher or similar to women's in 8 of the 12 countries (Figure 1 and Figure 2) (1). A comparative study of DHS from 13 African countries, including Ghana and Senegal, prior to the implementation of PITC and availability of ART (2003-2006) reports similar findings (46): less than 25% of men reported ever-testing and receiving the results of an HIV-test (46). Women were more likely to report ever-testing in five of the 13 countries (46).

Since 2004/5 gender differentials in HIV-testing uptake have emerged in DHS/AIS surveys (1, 46). Women's levels of HIV-testing increased dramatically since 2004 (Figure 1)(1). Men's levels of ever-testing also increased with time, however, the rate has been slower than that observed for females (Figure 2) (1). By 2010, over 50% of women reported ever-testing for HIV in more than half (n=7; 58%) of the 12 countries compared to 17% (n=2) of countries achieving 50% uptake among men. As such, the ratio of female to male ever-testing has shifted (Figure 3). In the eleven surveys conducted in nine countries prior to 2004, the ratio of female to male testing was less than one in 91% (n=10; Figure 9), illustrating the justified concern that women would be disadvantaged in their access to ART relative to men (42, 47, 48). Post-2004 the ratio of ever-testing for HIV shifted. In 92% (n=11) of the countries, the ratio of female to male HIV-testing exceeded one (Figure 3). Similar disparities emerge in HIV-testing and receipt of the results of an HIV-test in the last 12 months. In the 2005/6 Zimbabwe DHS, 7% of females and males reported a recent HIV-test compared to 34% of females and 20% of males in the 2010/11 DHS (45, 49).

Figures 1-3: The % of women (figure 1) and men (figure 2) who reported ever-testing for HIV and the ratio of female to male levels of ever-testing for HIV (figure 3) in 12 sub-Saharan African Countries, DHS/AIS, 1998-2012



Source: ICF International, 2012. The DHS Program STATcompiler http://www.statcompiler.com

2.3 The Gender Gap in HIV-testing in the Literature

The gender gap in ever-testing for HIV seen at national-level in DHS/AIS is mirrored in the literature on HIV-testing in sub-Saharan Africa. Studies published in the early 2000s generally report higher HIV-testing by men relative to women (1). Studies conducted post-2004 generally report the reverse trend. The increased availability of ART and VCT, and the implementation of PITC, provided men with increased access to HTC services (1). Yet, and although the prioritisation of PITC in ANC was warranted in light of women's disproportionate burden of HIV and the success of ART in PMTCT, the focus of HTC services on women has contributed to a gender gap in HIV-testing (50).

In an open cohort study in Eastern Zimbabwe, 7% of participants had ever received VCT at baseline (1998-2000) compared to 19% in the follow-up survey conducted three years post-baseline (51). Males were more likely to report receiving VCT than females (26% vs 14%). However, they were less likely to receive the result of an HIV-test relative to women (46% vs 71%) (51). A history of VCT was associated with age, area of residence, fewer total lifetime partners and a higher number of non-regular partners (51).

In a 2006/07 cohort in two outpatient settings in Durban, South Africa, 15% of women HIV-tested prior to study enrolment compared to 11% of men (52). By 2009/10, 49% of women reported a previous HIV-test relative to 34% of men (52). Overall, women were more likely to report HIV-testing (29% vs 21%; $p<0.01$) however there was no significant difference in changes in the rate of HIV-testing by sex over time (52). In 2006/07, multiple (2 or more) HIV-tests prior to study enrolment were reported by 5% of women compared to 3% of men. In 2009/10, 21% of women reported multiple-tests compared to 13% of men (52).

In a cohort in Rakai, Uganda, 56% of married men reported prior HTC in 2003/4 with levels similar among married females (55%)(53). By 2008/9, 35% of men reported prior HTC compared to 48% of women. Never-testing for HIV was higher among males, those aged 15-24 and those with less education (53). In a community-based cohort in rural Tanzania (2003-2004), 2% of men reported previous VCT compared to 1% of women (54). Individuals were offered VCT at a hut within the community and could return for results one week post-VCT. Overall, 12% of males and 7% of females completed VCT (54). Men living with HIV for less than 5 years were more likely to access VCT than HIV-negative males (54). This pattern was not observed among females, prompting authors to caution that females in need of ART may be less likely to access VCT and be linked to care (54).

In a 2003 survey of sexually active South African youth aged 15-24 years, 17% of males ever-tested for HIV compared to 33% of females (55). Males aged 20-24 were more likely to test relative to those aged 15-19. Higher education, ever starting a conversation about HIV and increasing visits to a health clinic were positively associated with ever HIV-testing among males (55). In a survey in rural South Africa (2004), 28% of respondents ever-tested for HIV (56). Females were more likely to test than males (37% vs 13%, respectively) (56). The sampled population may be unrepresentative of the wider population as the sample was non-random and surveys were conducted during working hours in the week (56). Nonetheless, the study highlights low levels of HIV-testing in the early half of the decade and points towards an emerging gender disparity in HIV-testing in South Africa.

In a population-based survey in rural Uganda (2005), some 23% of men reported complete VCT (defined as pre-test counselling and receipt of results) (57). Drop-out from the VCT cascade was high, with 44% of men pre-test counselled not completing VCT (57). Men aged 35 years and older were less likely to complete VCT relative to those aged less than 35 and education was positively associated with ever-testing (57). Some 11% of men in a nationally representative survey conducted in 2005 in Cote d'Ivoire, where HIV prevalence was estimated at 3.4%, reported ever-testing for HIV (58). A recent HIV-test (defined as testing within the last 2 years) was reported by 6% of men (58). For women, levels were 15% and 10%, respectively. Among women reporting a recent-test, 48% tested through ANC (58).

In 2005, the Kenyan Ministry of Health launched a policy for the implementation of PITC in health facilities. In a 2006 survey conducted in Kisumu, Kenya, 47% of women ever-tested compared to 36% of men (59). Among men, the prevalence of ever-testing was higher among those with college/university education (62%) compared with men with secondary (37%) or primary (26%) education (59). In a 2007 survey in urban South Africa, 29% of men ever-tested compared to 65% of women (60). Some 17% of men and 44% of women reported testing in the 12 months preceding the survey (60). Among ever-testers, 61% of females and 50% of males reported repeated HIV-testing (60). Ever-testing was associated with being aged older than 23 years, more years of education and employment (60). Sexual behaviours, including currently having a sexual partner, were also associated with ever-testing among men, as was having heard of ART and conversations about HIV (60).

2.4 The Need to Reach Men with HIV-Testing and Counselling Services

Fewer men in need of ART access treatment compared to women (42). In Kenya, Mozambique, Rwanda and Tanzania, despite declines in enrolment at advanced disease stages, men continue to access ART at later stages of HIV-infection relative to women (61). For example, in 2011, some 66% of men living with HIV enrolled late into care, as defined by WHO 2010 treatment guidelines, compared with 56% of non-pregnant and 29% of pregnant women (61). Studies from Mozambique and Zimbabwe report similar findings (42, 62, 63). In a systematic review of 21 reports from southern Africa, proportionately more women accessed ART than men even after accounting for gender differences in HIV prevalence (42, 62, 63).

Men are considered reluctant to access preventative health services, with evidence of this phenomenon arising from Brazil (64), the United States (65), Tanzania (66) and Zimbabwe (18). Studies suggest that this reluctance is associated with a complex interplay between social and economic norms associated with perceptions of masculinity (18).

Barriers to men's access to HTC services in health facility settings include distance (18), fear, stigma, denial and a low perceived risk of HIV (18, 67, 68). Studies of men's access to HIV services from sub Saharan Africa highlight that men are expected to be "strong" and "disease free" and that the "patient persona" conflicts with these expectations (18, 69). Economic reasons contribute to men's reluctance to access services. With men often responsible for the household income, the direct and opportunity costs associated with taking time to seek healthcare services is high (18, 70, 71).

With HIV prevention historically targeted at women and pregnant women in particular (6, 7, 50, 72), studies from Ghana, Malawi and South Africa, highlight that clinics are often perceived by men to be "female" spaces (73-75). Men's reluctance to access available health services may reflect the priority placed on maternal and child health in the context of HIV across much of sub-Saharan Africa (50, 72, 76). These barriers are illustrative of why PITC may have had less impact on men's levels of HIV-testing compared to women's. In the absence of a comparable HTC initiative targeted at men, men's levels of HIV-testing may continue to lag behind women's.

The implications of men's poor uptake of HTC services extend beyond linking men testing HIV-positive to treatment and care services. A high proportion of incident infections are acquired within sero-discordant married/cohabiting couples (77, 78). As the primary decision-makers within couples in many countries in sub-Saharan Africa, men's HIV-testing is critical not only to their own health, but to women's health and PMTCT efforts (79-81). Individuals receiving VCT reduce their reported number of sexual partners and individuals testing HIV-positive are more likely to report condom use relative to individuals not receiving VCT (82). Since 2012, WHO has recommended that partners and couples be offered HTC services, including in ANC settings, with support for mutual disclosure and sero-discordant couples offered ART for prevention purposes (83). Couples HTC with mutual disclosure increases condom use and uptake of PMTCT services (82, 84-86). In a study in Tanzania, pregnant women whose male partner participated in HTC had increased nevirapine use and adherence to recommended infant feeding relative to pregnant women whose male partner did not attend ANC (87). Similar findings were reported in a cohort study promoting couples HTC in Kenya (80). In a Zambian study, women counselled as a couple were more likely to accept HIV-testing compared with women counselled alone (88). In an RCT in Tanzania (2003/4), a lower proportion of women in the couples HTC arm received the results of their HIV-test than women randomised to individual HTC (39% vs 71%) (89). However, among women testing HIV-positive, those receiving couples HTC were more likely to use nevirapine (89).

Various strategies have been implemented to involve men in HIV-prevention initiatives (72, 90). To encourage their participation in ANC, longer clinic hours have been offered, women attending with their male partner given priority over women attending alone and letters of invitation offered to men to attend ANC (79, 81, 91). Others have aimed to decrease gender-based violence and/or reduce risky sexual behaviours (92), including training sessions with men recruited from townships in Cape Town, South Africa (93), counselling to sexually transmitted infection (STI) clinic patients to reduce HIV risk behaviours (94) and the Stepping Stones intervention, a series of workshops targeting behaviour change among South African youth to reduce HIV incidence (95). Evidence that male circumcision could reduce men's risk of HIV-infection led WHO and UNAIDS to recommend the scale-up of voluntary medical male circumcision (VMMC) services in 14 countries including Mozambique, Zambia and Zimbabwe (20-22, 96). The scale-up of VMMC services provides an opportunity to give men access to HTC and condoms (23), and may contribute to normalising HIV-testing among all men (Section 3.3). Many of these initiatives, particularly those encouraging men's access to ANC, have reiterated the challenges in reaching men with HIV-prevention services.

2.5 Current Strategies to Increase Population-Levels of HIV-Testing

Recognising the limitations of relying solely on facility-based HTC to provide universal access to HIV-testing services, various countries in sub-Saharan Africa have adopted community-based HIV-testing policies and WHO developed a framework for delivering HTC through a range of community-based settings (7, 97). Community based HTC offers services at home, at the workplace, through mobile vans within communities or through outreach in non-health facility buildings, including schools or community halls (97). By removing several barriers to accessing HTC that are unique to men, community-based delivery is expected to be more effective at increasing men's uptake of HTC than facility-based services (97).

Among the countries implementing national HIV-testing campaigns to deliver HTC services at scale through community-based modalities is Lesotho, initiating "universal" VCT in 2004 (97, 98). An HTC campaign was launched in 2006 to achieve knowledge of HIV status among all individuals aged 12 years and older. The campaign used community mobilization and engagement, offered all households HTC and linkage to prevention and care services as appropriate (97).

In 2010, South Africa launched a campaign to test 15 million people by 2011, a three-fold increase from 2.5 million in 2009 (99). During the campaign, the number of mobile and standalone HTC sites was increased and extensive community mobilization conducted. In a nationally representative survey (2012), 59% of males relative to 72% of females ever-tested. Some 65% of males reported testing within the year preceding the survey compared to 52% in a 2008 survey (100). Some 45% of women testing HIV-positive were not aware of their status compared with

62% of males (100). Although the survey did not aim to assess the campaign's effectiveness, the findings suggest that men's increase in HIV-testing may have been in part attributable to the campaign (100).

2.6 Preamble to Research Paper I: Systematic review of strategies to increase men's HIV-testing in sub-Saharan Africa

The delivery of HTC services within community-based settings should increase men's uptake of HIV-testing by providing services at locations and times expected to be more convenient to men. Evidence of whether these strategies are effective at increasing men's levels of HIV testing is required. Such evidence could support resource planning and allocation in countries where men are among the population hardest to reach with HTC services.

Previous systematic reviews of HIV-testing have explored the contribution of PITC to universal HIV-testing by pregnant women attending ANC (6); the effect of home-based HIV-testing on testing uptake (101), which identified one RCT and concluded that there was limited evidence to recommend scale-up; the acceptability of home-based HIV-testing (102); and the effectiveness of community-based HIV-testing initiatives (103) in various contexts, which included observational studies and two trials. No existing systematic review explored whether facility- and community-based strategies were effective at increasing men's uptake of HIV-testing services and the size of these effects. Research Paper I of this thesis aimed to address this gap in the evidence. The paper is a systematic review of the published literature on interventions to increase HIV-testing in sub Saharan Africa with a focus on the effectiveness of these strategies in increasing men's HIV-testing.

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SECTION A – Student Details

Student	Bernadette Hensen
Principal Supervisor	James Hargreaves
Thesis Title	Increasing men's uptake of HIV-testing in sub-Saharan Africa: a systematic review of interventions and analyses of population-based data from rural Zambia

If the Research Paper has previously been published please complete Section B, if not please move to Section C

SECTION B – Paper already published

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For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I conceived the idea for the review with James Hargreaves. I developed and ran the search, lead the screening of the retrieved references and the assessment of the risk of bias of eligible papers. I extracted the data from the eligible papers. I wrote the first draft of the manuscript and responded to comments

	where appropriate

Student Signature: BHansen **Date:** 15/7/15

Supervisor Signature: [signature] **Date:** 14/7/15

2.7 Research Paper I

Systematic review of strategies to increase men's HIV-testing in sub-Saharan Africa

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Objective: This systematic review summarizes evidence on the effectiveness of strategies to increase men's HIV-testing in sub-Saharan Africa.

Methods: Medline, EmBase, Africa-Wide Information and Global Health were searched. Cluster and individually randomized trials evaluating interventions to increase the proportion of adults (≥15 years) testing for HIV were eligible if they were conducted in sub-Saharan Africa, included men in the study population, and reported HIV-testing data by sex. References were independently screened.

Results: Of the 1852 references, 15 papers including 16 trials were eligible. Trials were judged too heterogeneous to combine in meta-analysis. Three interventions invited men to attend antenatal care-based HIV-testing via pregnant partners, of which two showed a significant effect on partner-testing. One intervention invited men to HIV-test through pregnant partners and showed an increase in HIV-testing when it was offered in bars compared with health facilities. A trial of notification to partners of newly diagnosed HIV-positive patients showed an increase in testing where notification was by health-care providers compared with notification by the patient. Three interventions reached men already at health facilities and eight reported the effects of community-based HIV-testing. Mobile-testing had a significant effect on HIV-testing compared with standard voluntary counselling and testing. Home-based testing also had a significant effect, but reached smaller numbers of men than mobile-testing.

Discussion: Interventions to encourage HIV-testing can increase men's levels of HIV-testing. Community-based programmes in particular had a large effect on population levels of HIV-testing. More data on costs and potential population impact of these approaches over different time-horizons would aid policy-makers in planning resource allocation to increase male HIV-testing.

Introduction

Sub-Saharan Africa remains the region most affected by HIV, with 70% of the infections in 2012 occurring in the region [1]. The proportion of individuals aware of their HIV status remains low, despite the scale-up of standalone voluntary counselling and testing (VCT) sites and provider-initiated HIV-testing and counselling (PITC) in health facilities [2–5]. A 2006–2011 study in four sub-Saharan African countries highlights that declines in the proportion of HIV patients enrolling into care with advanced illness have been moderate [6]. Antiretroviral therapy (ART) is less effective when accessed at later stages of immune suppression [7]. In light of their findings, the authors emphasize the need to increase efforts to expand HIV-testing and improve linkage to care for HIV-positive individuals [6]. Furthermore, opportunities to provide HIV-negative individuals and sero-discordant couples with access to prevention services are limited in settings where HIV-testing is low.

Whereas women's HIV-testing and counselling (HTC) has increased since 2004, partly due to PITC implementation in antenatal care (ANC) [3,8], men's HIV-testing rates remain lower than women's across sub-Saharan Africa [2,9–11]. ART uptake is lower among HIV-infected men; men access ART at later stages of immune suppression and experience higher mortality once initiated on ART [12,13]. Approaches to increase HIV-testing rates among men are urgently needed. To date, no systematic review of interventions to increase men's HIV-testing in sub-Saharan Africa exists. Consolidated evidence of strategies that effectively reach men with HIV-testing services would support resource allocation in countries where men's testing is low. We systematically reviewed randomized controlled trials (RCTs) of interventions to increase HIV-testing among men in sub-Saharan Africa.

Methods

Medline, EmBase, Africa-Wide Information and Global Health were searched using combinations of search terms (Annex 2, http://links.lww.com/QAD/A567). Final searches were conducted on 25 October 2013. RCTs of interventions aimed at increasing the proportion of adults, including men testing for HIV, were included. Data on the proportion of men tested after intervention implementation and on the effect size of interventions compared with control are reported.

This systematic review is reported in line with the 2009 'Preferred Reporting Items for Systematic reviews and Meta-Analyses' (PRISMA) guidelines where applicable (Annex 1, http://links.lww.com/QAD/A567) [14]. No protocol exists.

Screening references

References were independently screened for eligibility (B.H./S.T.) and removed after abstract or full-text review. Where reviewers did not agree on eligibility, a third author (J.H.) was consulted.

Inclusion criteria

Studies were eligible if they evaluated interventions to increase HTC uptake by adults (≥15 years), described the proportion of individuals testing for HIV after intervention implementation, were cluster (CRT) or individually RCTs, included men in the study population and HIV-testing data were stratified by sex, and were conducted in sub-Saharan Africa. If sex-disaggregated data were unavailable, up to three attempts were made to contact authors via e-mail. If authors confirmed that sex-disaggregated data were not available, trials were included if more than 40% of the population in all trial arms were men (n=1) [15], but excluded when less than 40% were men (n=1) [16]. Conference abstracts, commentaries and letters were excluded due to lack of detailed information on trial design. No language, date or other restrictions were applied.

Data extraction and analysis

Data on the proportion of men HIV-testing after intervention in all arms were extracted (B.H.). Crude and adjusted risk ratios (RR) and 95% confidence intervals (95% CIs) were extracted when reported. Unadjusted RR were calculated from raw data using EpiInfo or Stata 12.0 with

95% CI reported for individually randomized trials. Odds ratios (ORs) or prevalence ratios were extracted if reported.

Two reviewers (B.H./S.T.) independently appraised trials for potential risk of bias using the Cochrane Collaboration risk of bias tool [17]. Risk of bias assessments were relative judgements made by two reviewers that relied primarily on reporting. Five domains were assigned: 'low', 'high' or 'unclear' risk of bias (Table 2) [17]. For CRTs, recruitment bias, baseline imbalances, missing outcome data on clusters and whether analyses adjusted for clustering were also assessed. Selective reporting bias was not assessed as eligibility included reporting on HIV-testing outcomes. Disagreements were resolved through consultation. Trials were not excluded based on risk of bias.

Results

The literature search identified 1852 titles. Abstract review removed 1796 titles and full-text review excluded 40 (Fig. 1). Of the 16 remaining trials, one was removed as authors confirmed that data by sex were unavailable and less than 40% of the study population were men [16]. Fifteen papers were eligible. One paper presented data for trials conducted in two sub-Saharan African countries, and a second reported on a trial conducted in four countries of which one was in sub-Saharan Africa [18,19] (Table 1).

Trials included in the review were heterogeneous (Table 1). Four evaluated interventions targeting men through pregnant partners [19–22], one targeted partners of newly diagnosed HIV-positive individuals [23], three evaluated interventions to increase HIV-testing among men attending healthcare facilities [15,24,25]. The remainder offered HIV-testing outside of the facility settings [18,26–31]. Target populations also differed. A meta-analysis was therefore not performed. The proportion of men testing in intervention arms was plotted against the proportion testing in control arms (Fig. 2).

Risk of bias

An assessment of the risk of bias across all trials was not performed due to heterogeneity. Six trials were assigned an unclear risk of selection bias as details of sequence generation and concealment were considered insufficient (Table 2). Blinding of intervention personnel/participants was reported in four trials with additional detail obtained from supporting information for two trials. Six trials were considered to have a low risk of performance bias and three a potential high risk. In one CRT, though matched, it was unclear whether baseline imbalances had been explored and adjustment for clustering made, though the latter would not bias the effect estimate.

Invitations through pregnant partners

Four interventions aimed to increase HIV-testing among men with a pregnant partner attending ANC [19–22] (Tables 1 and 3; Fig. 2). In a South African trial, pregnant women in the intervention arm received invitations for their partners to attend ANC-based VCT. The control arm received an invitation for partners to attend pregnancy information sessions [20]. In the intervention arm, 32% (n=161/500) of partners tested for HIV compared with 11% (n=57/500) in the control arm (RR 2.82, 95% CI 2.14–3.72).

In a Ugandan trial, an invitation requesting partners to attend the next ANC visit showed a similar effect compared with providing partners an information letter [21]. Sixteen percent (n=82/530) of partners in the intervention arm tested compared with 13% (n=68/530) in the control arm (RR 1.21, 95% CI 0.90–1.62).

A RCT in Cameroon randomized women who had tested in ANC to couple-oriented post-test counselling or standard counselling [19]. HIV-testing among men was defined as HIV-testing at any site as reported by female partners [intervention 23% (n=56/239); control 14% (n=35/245)] and/or logbooks of testing on-site [log-book-only intervention: 15% (n=35/239); control 6% (n=14/245)]. The intervention showed a stronger effect when measures were based on logbooks (RR 2.56, 95% CI 1.42–4.64) compared with combining logbook and self-report (RR 1.73, 95% CI 1.18–2.52).

A RCT in Democratic Republic of Congo offered pregnant women invitations for their partner to attend church or bar-based HTC [22]. Partners of women randomized to control were offered invitations for health facility-based HTC. Eighteen percent (n=166/909) of men randomized to health facility-based HTC were tested compared with 21% (n=189/906) randomized to a church and 27% (n=236/891) randomized to bar-based HIV-testing (adjusted OR: church 1.10, 95% CI 0.87–1.39; bar 1.50, 95% CI 1.19–1.89).

Facility-based HIV-testing and counselling through partner notification

In a RCT in Malawi, newly diagnosed HIV patients attending a sexually transmitted infection (STI) clinic were randomized to one of the three modes of partner notification (Table 1) [23]. In the provider referral arm, 44% (n=23/52) of the male partners were HIV-tested, in the contract referral, 46% (n=23/50) were tested, whereas in the passive referral arm, 15% (n=7/48) were tested (RR provider 3.03, 95% CI 1.43–6.42; contract 3.15, 95% CI 1.49–6.66).

Reaching men attending health facilities

Three trials reached men in health facilities. In a South African RCT, patients attending a STI clinic were randomized to risk-reduction counselling or a 20-min HIV information/education session [15]. Of the 228 patients, 66% (n=151) were men. In the intention-to-treat analyses, 38% (n=43/114) of the patients in the intervention arm reported HIV-testing 1 month after counselling versus 22% (n=25/114) in the control arm (RR 1.72; 95% CI 1.13–2.62).

In a CRT of opt-out PITC on tuberculosis (TB) patients HIV-testing in primary healthcare clinics in South Africa, 19% of male TB patients offered PITC tested compared with 8% in 'opt-in' clinics (OR 2.40, 95% CI 1.05–5.50; Table 3) [25].

A RCT in Uganda compared HIV-testing among in-patients offered PITC to HIV-testing among patients offered vouchers for HTC 1 week after discharge [24]. All male patients in the PITC arm (n=109) were tested compared with 65% (n=62/96) of men who were offered a voucher (RR 1.55, 95% CI 1.34–1.80) [24].

Reaching men in community settings

Eight trials evaluated interventions to reach individuals in community settings. In each trial, men in the intervention had higher levels of ever-testing (Table 3). In a CRT in Zimbabwe, businesses were randomized to on-site HTC or vouchers for off-site HTC. In the intervention sites, 55% of the male employees were HIV-tested. In control sites, 14% of male employees accepted vouchers (adjusted RR for men and women 2.8, 95% CI 1.8–3.8) [31]. Mean reported use of off-site VCT by men and women was 4.3% (adjusted RR: 12.5, 95% CI 8.2–16.8) [31].

In a RCT in Swaziland, 204 students were randomized to an intervention aimed at changing HIV-related knowledge, attitudes and behaviours, or control [30]. Among males aged at least 15 years with complete HIV-testing history data after intervention, 48% (n=15/31) randomized to intervention reported testing after intervention versus 7% (n=2/31) in control (RR 7.50, 95% CI 1.87– 30.08) [30].

Service utilization data from a CRT of mobile-testing in Tanzania and Zimbabwe reported significantly higher HTC in communities randomized to mobile HTC, compared with HTC in communities randomized to standard VCT [18]. In Tanzania, testing was approximately five times higher in intervention com-munities [18], with an estimated 44% of men tested compared with 9% the in control communities. In Zimbabwe, testing was approximately 10 times higher in the intervention communities [18], an estimated 53% of men tested compared with 5% in control communities.

A sub-study of a CRT in Uganda compared HIV-testing among households offered home-based HTC with HTC among households offered vouchers for facility-based HTC [26]. The primary trial outcome was mortality among ART patients randomized to home or clinic-based ART delivery [32]. The sub-study targeted household members of the index-ART patient, with household members of patients randomized to home-based ART offered home-based HIV-testing, and household members of patients randomized to facility-based ART offered vouchers for facility-based HTC. Male household members aged at least 15 years in the home-based arm were significantly more likely to test compared with that in the comparison arm (45% versus 9%; RR 4.96, 95% CI 3.71–6.63) [26].

Two CRTs reported the effect of home-based HTC compared with standard of care (Table 1) [27,29]. In South Africa, 47% of men in intervention clusters reported HIV-testing during the study period compared with 33% in control clusters (PR 1.52, 95% CI 1.19–1.95) [27]. In Zambia, 76% of men in intervention clusters reported HIV-testing in the year prior to the follow-up survey compared with 42% in control clusters (RR 1.8, 95% CI 1.4–2.3). In a CRT of home-based HTC in Kenya, 93% (n=580/626) of men in intervention communities reported ever-testing in a survey conducted 18 months after intervention versus 54% (n=351/655) in control communities [28].

Discussion

This is the first systematic review of the impact of interventions to increase HIV-testing on men's HIV-testing in sub-Saharan Africa. Previous systematic reviews of HTC explored the contribution of PITC to universal testing of pregnant women [3], determined the effect of home-based HTC compared with facility-based services [33] or the acceptability of home-based HTC [34] or reviewed evidence from community-based HTC studies [50]. Our review suggests that interventions to increase men's testing in sub-Saharan Africa are available, although few interventions targeted men specifically. Increasing men's population levels of HIV-testing provides opportunities to link men to HIV-treatment, prevention and care services. Furthermore, with the evidence that men's HIV-testing is associated with women's uptake and adherence to prevention of mother-to-child transmission (PMTCT) [35,36], men's HIV-testing is crucial to the success of PMTCT interventions and for women's health [9]. Evidence arising from this review may support decision-making by the HTC implementers in countries where men's HIV-testing is low. With four trials conducted in South Africa, evidence arising from these interventions may support HTC implementers operating in this region in developing strategies to target men with HIV-testing services.

This review is subject to limitations. Inclusion was limited to published trials and it may be subject to publication bias, as null-effect interventions may be less likely to be published. As inclusion was not restricted to a specific male population or mode of HTC service delivery, the review includes heterogeneous trials. Combining the evidence to determine overall intervention effects was challenging. We therefore did not perform a meta-analysis or compare results across interventions. To increase comparability, strict study design criteria were applied. However, by including this restriction, we excluded observational studies, which have been included in reviews of home-based HTC and may provide additional evidence in support of our findings [34]. Although heterogeneous, evidence across the trials is consistent, with HIV-testing higher in intervention sites in all trials, highlighting that interventions to increase men's HIV-testing are available.

Trials included in the review may be subject to limitations. The potential for bias in trials that did not report details of how the random sequence was generated or whether allocation was concealed was considered unclear. In a CRT, an HIV-prevention organization working with businesses assisted in selection of businesses to be included in the trial. As such, the selected businesses may have been more responsive to the intervention [31]. Bias may be present in trials of invitations to partners as women may have opened sealed envelopes [22]. Knowledge that partners were invited to ANC [21] or where they would be offered VCT [22] may have deterred women from providing letters to their partners [22]. However, as highlighted by Ditekemena et al. (2011), it is unclear what effect this bias would have on outcomes [22]. Outcome measurement was at risk of bias in some trials in which these were self-reported, as individuals may over-report previous testing due to social desirability bias [27–29].

All trials show large and consistent effects on men's HIV-testing. In trials included in this review, men's attendance to ANC was low at 16–30% consistent with other research [35–37].

Nonetheless, ANC-based strategies have the potential to increase men's HIV-testing. Evidence suggests that couple-HTC increases HIV-positive pregnant women's use of nevirapine for PMTCT and their own health [35,36]. HIV-testing by partners of HIV-positive pregnant women is crucial for PMTCT and women's health [22]. Three-quarters of individuals aged 20–49 years residing in sub-Saharan Africa report cohabiting [38]. With many cohabiting men likely to have a pregnant partner in the course of their relationship, ANC-based HTC has the potential to reach a high proportion of these men [38]. To increase men's ANC-based HIV-testing, promotional campaigns to normalize their ANC attendance may prove effective. Although limited to one trial, the RCT that promoted men's participation had a greater effect than trials with no sensitization directed at men [20]. With little evidence of the impact and cost-effectiveness of promotional campaigns on HTC acceptance in developing countries additional research is warranted.

Couple-HTC is being promoted principally in ANC [36–39]. As few men attend clinics considered 'female' environments, couple-HTC should be available in alternate settings including voluntary medical male circumcision (VMMC) clinics and mobile HTC [38,40]. These settings may not only prove more acceptable to men and some women but may encourage couple-HTC by non-pregnant couples. Home-based testing is an additional strategy that may prove more effective at reaching couples. In the South African home-based HTC trial, the prevalence of couple-HTC in the intervention arm was two times higher than in control (RR 2.24, 95% CI 1.49–3.03) [27]. In the Zambian trial, 62% of cohabiting respondents reported being counselled with their partner [29]. Among those tested at home, 70% reported that they received their test result with their partner [29].

Men may be reluctant to access health services due to norms associated with masculinity, including being strong and 'disease-free', that may act as a barrier to seeking preventive healthcare services [41]. Men's access to HTC and HIV services may be limited further by fear and perceived lack of confidentiality of services [42–44]. With limited access to healthcare, PITC has reached few men compared with women, despite increased incentives to HIV-test with increasing ART availability [45,46]. Studies have shown that PITC is acceptable [47,48] and diagnoses a high proportion of HIV-positive individuals among those tested at relatively low costs per individual tested [45]. PITC trials included in this review showed a large effect on HIV-testing [25]. In VMMC clinics in Tanzania, 99% of men accepted PITC when offered [49]. However, the majority were young and at low risk of infection [49]. The need for interventions to reach older men therefore remains [49]. Although PITC is unlikely to increase men's population levels of HIV-testing, the strategy can reach a high proportion of men already engaged with health services [50]. PITC is an important mode of service delivery, particularly in generalized epidemics, but PITC alone will not provide men with universal HTC access [50].

Community-based HTC strategies providing services outside of health facilities may prove more acceptable to men than facility-based initiatives [16,36]. Mobile-testing, where services are offered through caravans or tents, in particular, could have a large impact on population levels of HIV-testing by reaching a high number and proportion of men. In the CRT of mobile-HTC included in this review, mobile-testing increased men's HIV-testing by 45% ($P < 0.001$) across all countries (including Thailand), relative to VCT [51]. Post-intervention survey data from a random sample of men aged 18–32 years showed an increase in HIV-testing in Tanzania from 16% at baseline to 26% in intervention communities, compared with no increase from 6% in control communities [51]. In Zimbabwe, HIV-testing increased from 3% to 25% in the intervention communities compared with 3% to 16% in the control communities [51]. Cost analyses in Kenya show that fully mobile HTC costs approximately $23 per first-time tester compared with $44 at standalone VCT [52]. Although studies show that mobile-testing detects a lower proportion of HIV-positive individuals than facility-based testing, it has the potential to reach a large number of men, particularly those with no history of testing [50,52]. To improve cost-effectiveness and reach, integrated campaigns that deliver a package of interventions, including VMMC and condoms, could be delivered [53,54]. Workplace-HTC reached a relatively high proportion of employed men and is expected to bear little cost to governments [31]. It may be effective at reaching men not at home during home or mobile-HTC campaigns. Nonetheless, even if fully integrated in employment settings, large numbers of men will not have access to workplace-HTC in settings where formal employment is low.

Home-based HTC also had a large effect on HIV-testing. A systematic review of home-based HTC acceptability shows that overall men found at home are as likely as women to be offered testing and to accept an offer of home-based HTC [34]. However, in some studies, the proportion of individuals found at home that were male was low [55]. Home-based HTC may have limited impact on population levels of HIV-testing in areas of high mobility for employment and in the absence of repeat visits to find men who are less likely to be at home. As such, increasing men's HIV-testing at population level through home-based HTC may prove less cost-effective as repeated visits would increase delivery costs [34,56]. Home-based HIV-testing identifies a lower proportion of HIV-positive men among men tested compared with PITC, yet individuals are likely to be identified at earlier stages of infection [34,45]. Home-based testing is an effective strategy that reaches a high proportion of those targeted in addition to increasing couple-HTC [27]. Furthermore, offering home-based HTC may provide an opportunity for counselling and to reach first-time testers. In the Zambian trial, 84% of men accepted counselling services [29]. First-time testing was higher in the intervention arms of the Zambian and South African trial; in Zambia, the prevalence of first-time testing was 68% in the intervention arm versus 29% in the control arm [57]. In South Africa, 46% of all testers in the intervention arm were first-time testers compared with 37% in the control arm [27]. Home-based testing is therefore an important strategy to be delivered alongside other models of HIV-testing [34,50,58].

HIV self-testing is an additional strategy that may prove effective at increasing men's population levels of HIV-testing. A feasibility study conducted in Malawi suggests that home-based self-testing was men's preferred option for future testing [59]. Additional research in developing countries is needed including population-level impact, cost-effectiveness, how to deliver HIV tests, and linkage to HIV prevention and care; yet the model remains a promising alternative to healthcare provider-delivered HIV-testing [59].

Timely diagnosis of HIV infection is crucial to the effectiveness of treatment as prevention initiatives [56]. Strategies that not only encourage first-time testing but also repeat-testing, particularly by high-risk HIV-negative individuals, are required [56]. In the Zambian trial, repeat-testing was higher in intervention communities (94 versus 74%; $p<0.001$) [57]. The trial of mobile-testing reports that at the end of the intervention period, approximately 40% of the individuals attending mobile-testing clinics in the three trial countries (including Thailand) were repeating an HIV test within the clinics [18]. Additional research is required to determine the impact of community-based strategies on repeat-testing and whether these modalities encourage repeat-testing by individuals at increased risk of HIV infection [60].

In conclusion, this review provides evidence that interventions to increase HIV-testing are effective at reaching men. To increase men's HIV-testing at a population level, country and time-specific combinations of available strategies are likely to be required [58]. Additional research to determine whether these strategies encourage repeat-testing by high-risk HIV-negative men is required to support decision-making in countries opting for treatment as prevention initiatives.

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Figure 1. Flowchart of study inclusion

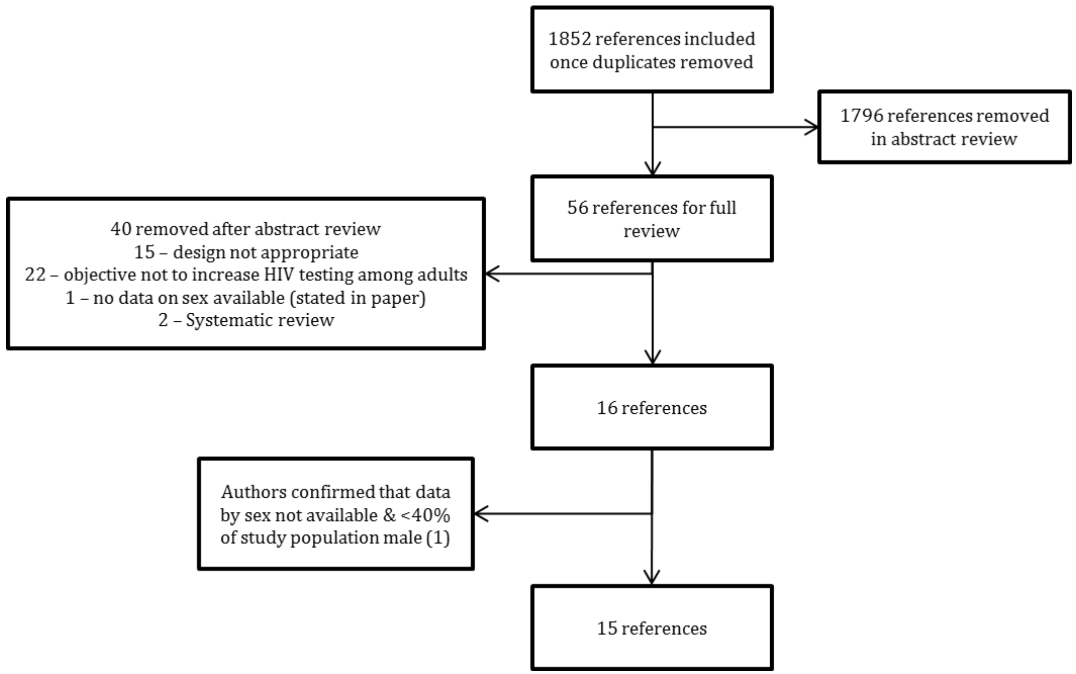


Table 1. Characteristics of the trials eligible for inclusion.

First author, publication year	Country & setting	Study period	Study design	Study objectives	Study population	Recruitment	Sample size	Intervention or policy	Comparison group
Invitations for ANC-based HTC provided through pregnant women									
Mohlala, 2011 [20]	South Africa, urban ANC clinic	Nov 2006-Dec 2007	RCT	To compare women's acceptance of written invitations for VCT and pregnancy information sessions (PIS) for male sexual partner (MSP) and uptake of VCT by MSP	Pregnant women at <30 weeks gestation and their MSP	Consecutive women attending ANC without MSP; MSP recruited through women	1000 pregnant women; 500 intervention, 500 in control	Written invitation for MSP to attend ANC the for VCT along with community sensitisation 9 months before the intervention during follow-up and recruitment	Written invitation for MSP to attend PIS and offered VCT 12 weeks after the initial visit
Byamugisha, 2011 [21]	Uganda, ANC at a referral hospital	Oct 2009–Feb 2010	RCT	To evaluate the effect of an invitation letter on couples attendance to ANC and VCT uptake by MSP within a 4- week follow-up period	Pregnant women (≥15 years) attending their first ANC visit and their MSP	Women attending ANC without MSP who were willing to return within 4 weeks identified at reception and approached by research assistant; MSP recruited through women	1060 pregnant women; 530 intervention 530 control	Invitation letter addressed to MSP to attend subsequent ANC visit	A leaflet containing information on the services available at the ANC

First author, publication year	Country & setting	Study period	Study design	Study objectives	Study population	Recruitment	Sample size	Intervention or policy	Comparison group
Orne-Gliemann, 2013 [19]	Cameroon, urban health centre	26 Feb–15 Oct 2009	RCT	To determine the impact of couple-oriented post-test counselling (COC) on partner HIV-testing	Pregnant women aged ≥15 years attending their first prenatal visit who agreed to 6 months of follow-up and their male partners	Women who were interested in participating and were eligible asked for written informed consent; male partners identified through women	484 women; 239 intervention arm 245 control arm	COC: develops women's communication skills and self-efficacy; empowering women and encouraging HTC-related discussion with partners	Standard post-test counselling
Invitations for community-based HTC provided through pregnant women									
Ditekemena, 2011 [22]	DRC, urban NHC, bar and church	1 Sept 2006–31 Jan 2007	RCT	To identify alternative strategies to increase participation in VCT by men whose pregnant female partner received HIV-testing	Male partners of pregnant women (≥18 years) who received VCT at ANC in maternity hospital	All women attending an ANC centre were provided information about the study and asked for consent	2706 pregnant women; 906 church arm, 891 bar arm, 909 NHC arm	Written invitation to attend VCT at a church or in a bar	Invitation to attend VCT in a neighbourhood health centre
Partner notification to invite individuals for HTC in health facilities									
Brown, 2011 [23]	Malawi, STI clinics in two urban hospitals	Oct 2008–Sept 2009	RCT	To determine the effectiveness of different methods of partner notification on notification rates and partner HTC uptake	Partners of STI clinic patients with newly diagnosed HIV infection	Selection of hospitals not reported. All patients (aged ≥18 years) testing positive for first time and sexually active within last 90 days invited to participate	Provider referral: 48 female index patients 52 male partners Con- tract referral: 46 female index patients 50 male partners	Provider: newly diagnosed patients given 48h before provider initiated partner contact Contract: newly diagnosed patients given 7 days to notify partners of their status	Passive referral to notify sexual partners and refer for HTC

First author, publication year	Country & setting	Study period	Study design	Study objectives	Study population	Recruitment	Sample size	Intervention or policy	Comparison group
							Passive referral: 46 female index patients 48 male partners		
Reaching men attending health facilities									
Simbayi, 2004 [15]	South Africa, STI clinic	Aug–Nov 2003	RCT	To test the efficacy of a brief theory-based HIV prevention counselling intervention for STI patients	Repeat STI patients	Repeat STI patients being treated for multiple STIs referred by nurse or physician	228 recruited; 151 (66%) male. 114 motivational / skills counselling 114 information, education	60 min theory-based information-motivation-behavioural skills risk reduction counselling to change knowledge, attitudes and behaviours and increase self-efficacy	20 min information and education session
Pope, 2008 [25]	South Africa, 20 primary care TB clinics	12 Aug–10 Nov 2005	CRT	To determine whether opt-out PITC increases the proportion of TB patients HIV-tested	Newly registered TB patients (≥18 years) who remained in care for ≥14 days	Clinics selected from 44 PHCs based on presence of TB nurse and min of 3 newly registered TB patients per month	10 intervention and 10 control clinics; 194 males intervention 238 males control	PITC, including training for nurses on the offer of HTC	Opt-in HIV testing

First author, publication year	Country & setting	Study period	Study design	Study objectives	Study population	Recruitment	Sample size	Intervention or policy	Comparison group
Wanyenze, 2011 [24]	Uganda, urban hospital	2004–2005	RCT	To compare the impact of inpatient HTC on HTC uptake, linkage to care and survival among inpatients compared with referral for VCT	Medical inpatients aged ≥18 years with unknown HIV status, residing within 20 km of hospital	Participants identified in consultation with medical teams; potential participants randomly selected from list of hospitalized patients	500 inpatients 109 males intervention 96 males control	PITC with next day results	Referral for HTC at the hospital 1 week after discharge
Reaching men in community settings									
Corbett, 2006 [31]	Zimbabwe, 22 urban businesses	2 years follow-up/site; last site complete d July 2004	CRT	To estimate the impact of on-site HTC on HTC uptake compared with referral to off-site VCT	Employees expected to remain employed for at least 3 months	Businesses identified with an HIV Prevention Project. Eligible if they had: 100–600 employees; a first aid clinic; individual based absenteeism	11 businesses and 2981 males intervention arm 11 businesses and 2474 males control arm	Counselling and on-site rapid HIV testing	Counselling and vouchers for off-site VCT at standalone centre. Two week appointment to discuss results

First author, publication year	Country & setting	Study period	Study design	Study objectives	Study population	Recruitment	Sample size	Intervention or policy	Comparison group
Burnett, 2010	Swaziland, secondary school	2006–2007	RCT	To evaluate the effect of an HIV education intervention on HIV- related behaviours including HIV-testing	Secondary students in form 2 (grade 9) or form 4 (grade 11)	All students eligible, 204 enrolled on a first-come first-served basis	93 students intervention group 84 control group Data provided for 115 male students aged ?15 years with complete outcome data post intervention	A 13-week life skills-based HIV education programmes to increase HIV knowledge, change attitudes and behaviours. Mobile HTC available at one session	No education programme (delayed intervention)
Sweat, 2011 [18]	Tanzania, 10 rural communiti es Zimbabwe, 8 rural communiti es	Mar 2006–Apr 2009 Jan 2006–July 2009	CRT	To examine whether mobile testing in combination with community mobilisation and post-test support increases HTC uptake compared with standard VCT	Adult populations (16–32 years) residing in selected communities	Ethnographic mapping used to select com- munity pairs matched on access to health services, economic activity, population density, civic organisation	Tanzania: 6250 individuals in intervention and 6733 in control communities Zimbabwe: 10700 individuals intervention, 12 150 control com- munities	Community-based HTC service delivery combined with community mobilisation and avail- ability of post-test sup- port	Standard clinic-based VCT

First author, publication year	Country & setting	Study period	Study design	Study objectives	Study population	Recruitment	Sample size	Intervention or policy	Comparison group
Lugada, 2011 [26]	Uganda, 44 clusters defined by geographical area in five districts	Feb 2005–Feb 2007	CRT	To compare HTC uptake among household members of index ART-patient offered home-based HTC to uptake among those offered vouchers for VCT	Household members of index ART-patients (results presented for males aged ≥15 years)	Cluster selection not defined. Index Patients aged ≥18 years recruited from an ART clinic	22 clusters intervention and 22 control arm: 947 male household members ≥15 years intervention 484 males household members ≥15 years control arm	Home-based HTC provided to household members of index ART-patients	Vouchers for free VCT given to index ART-patients to provide to household members
Doherty, 2013 [27]	South Africa, geographically similar rural clusters	Intervention: Sept 2009–Nov 2010 Survey: Feb –May 2011	CRT	To determine the effectiveness of home-based HTC compared with facility based testing	Household members aged 18 years and older; 14– 17-year-olds also eligible with guardian/parental consent	Geographical clusters randomized, all households in intervention clusters targeted	16 clusters; 8 intervention clusters, 484 men surveyed post intervention 8 control clusters, 578 men surveyed after intervention	HBHTC with extensive community mobilization	Standard of care: HTC services at local clinics and NGO outreach teams. Mobile HTC was implemented halfway through the study
Fylkesnes, 2013 [29]	Zambia, rural villages	Intervention: March–May 2010 Survey: Nov	CRT	To evaluate the acceptance of HBHTC compared with standard HTC services	Household members aged 18 years or older	Villages randomized, all households visited	36 clusters; 18 intervention clusters, 255 men surveyed post intervention 18	HBHTC with community mobilisation, radio spots and drama	Standard of care: VCT in health facilities and outreach by NGOs

First author, publication year	Country & setting	Study period	Study design	Study objectives	Study population	Recruitment	Sample size	Intervention or policy	Comparison group
		2010–Jan 2011					control clusters, 261 men surveyed post intervention		
Low, 2013 [28]	Kenya, administrative regions	Intervention: 2009 Survey: 2011	CRT	To evaluate the effects of HBHTC on HIV testing compared with no HBHTC	All households in intervention and control regions	Administrative regions randomized, randomly selected households surveyed	18 clusters; 9 intervention clusters, 626 men ≥15 years surveyed; 9 control clusters, 655 men ≥15 years surveyed	HBHTC	No offer of HBHTC

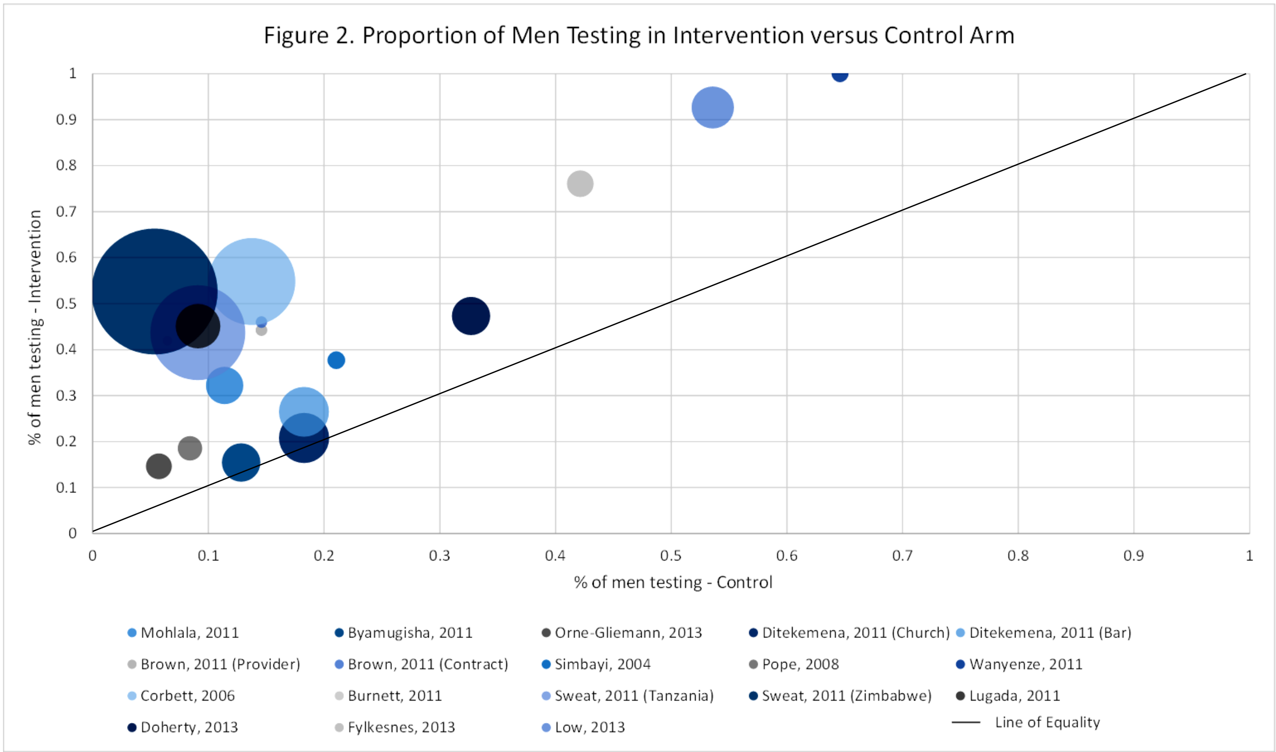
Key: ANC, antenatal care; ART, antiretroviral therapy; COC, couple-oriented counselling; CRT, cluster randomized trial; DRC, Democratic Republic of Congo; M, moderate; MSP, male sexual partner; NHC, neighbourhood health centre; PHC, primary healthcare; PIS, pregnancy information sessions; PITC, provider-initiated HIV-testing and counselling; QA, quality; RCT, randomized controlled trial; S, strong; VCT, voluntary counselling and testing.

Table 2. Assessment of Risk of Bias in Individual Trials

Study	Random sequence generation	Allocation concealment	Blinding of Participants and Personnel	Blinding of Outcome Assessment	Incomplete Outcome Data	Other Sources of Bias: eg. Social desirability	Recruitment bias	Incomplete outcome data - clusters	Baseline imbalances & clustering
	Selection bias		Performance Bias	Detection bias	Attrition bias		For CRTs		
Mohlala, 2011	-	-	+	?	?	?			
Byamugisha, 2011	-	-	-	?	+	?			
Orne-Gliemann, 2013	-	-	?	?	-	+			
Ditekemena, 2011	?	?	?	?	?	?			
Brown, 2011	?	?	?	-	+	?			
Simabyi, 2004	?	?	+	?	-	+			
Pope, 2008	-	-	+	-	-	?	-	-	-
Wanyenze, 2011	?	?	?	?	?	-			
Corbett, 2006	-	-	-	?	-	+	-	-	-
Burnett, 2010	?	?	?	?	+	+			
Sweat, 2011	-	-	-	-	-	-	-	-	-
Lugada, 2011	?	?	?	-	?	-	-	-	-
Doherty, 2013	-	-	-	-	?	+	-	-	-
Fylkesnes, 2013	-	-	-	+	?	+	-	-	-
Low, 2013	-	-	-	?	?	+	-	?	?

Key

-	**Risk of bias considered low**
?	Risk of bias considered unclear
+	Risk of bias considered high



Footnote 1. Simbayi, 2004: Outcomes for men and women; Corbett, 2006: Control is men's uptake of voucher for off-site VCT

Table 3. Proportion of Men Testing for HIV post-Intervention in Intervention and Control Arms

Study Reference	Outcome Measurement	Proportion HIV-testing Intervention (%, n) (A)	Proportion HIV-testing Control (%, n) (B)	Difference (%) (A-B)	RR (Unless otherwise reported) (95% CI)	Adjusted RR (Unless otherwise reported) (95% CI)
Invitations for ANC-based HTC Provided through Pregnant Women						
Mohlala, 2011	Num: # of men HIV-tested in study period Denom: # invited to ANC through pregnant partners	32.2 (161/500)	11.4 (57/500)	20.8	2.82 (2.14-3.72)	NR
Byamugisha, 2011	Num: # of men HIV-tested in study period Denom: # of men invited through pregnant partners	15.5 (82/530)	12.8 (68/530)	2.7	1.21 (0.90-1.62)[d]	OR: 1.6 (0.4, 6.8)[a]
Orne-Gliemann, 2013	Num: # of men HIV-tested in study period Denom: # pregnant women recruited	Logbook only: 14.6 (35/239) Combined: 24.7 (59/239)	Logbook only: 5.7 (14/245) Combined: 14.3 (35/245)	8.9 10.4	Logbook only: 2.56 (1.42-4.64)[d] Combined: 1.73 (1.18-2.52)[d]	Combined OR: 2.38 (1.41-4.02)[b]
Invitations for Community-based HTC Provided through Pregnant Women						
Ditekemena, 2011	Num: # of men HIV-tested in study period Denom: # of men invited to HTC site	Church: 20.9 (189/906) Bar: 26.5 (236/891)	18.3 (166/909)	Church: 2.6 Bar: 8.2	Church: 1.14 (0.95-1.38)[d] Bar: 1.45 (1.22-2.03)[d]	OR Church: 1.10 (0.87-1.39)[c] OR Bar: 1.50 (1.19-1.89)[c]
Invitations for Facility-Based HTC through Notification that Partner is Newly Diagnosed HIV-Positive						
Brown, 2011[o]	Num: # of male partners tested Denom: # of male partners identified by index patient	Provider: 44.2 (23/52) Contract: 46 (23/50)	Passive: 14.6 (7/48)	Provider:29.6 Contract:31.4	Provider: 3.03 (1.43-6.42)[d] Contract: 3.15 (1.49-6.66)[d]	NR
	Num: # of male partners tested Denom: # of locatable male partners identified by index patient	Provider: 47.9 (23/48) Contract: 48.9 (23/47)	Passive: 16.0 (7/45)	Provider:31.9 Contract:32.9	Provider: 3.08 (1.47-6.47)[d] Contract: 3.15 (1.50-6.60)[d]	NR

		Health Facility-based Strategies				
Simbayi, 2004	Num: # of individuals reporting testing 1mth post-counselling Denom: # of individuals in study arm	37.7 (43/114)	21.9 (25/114)	15.8	1.72 (1.13-2.62)[d]	OR: 2.4[e]
	Num: # of individuals reporting testing 1mth before 3mth follow-up Denom: # of individuals in study arm	30.7 (35/114)	25.4 (29/114)	5.3	1.21 (0.79-1.83)[d]	OR: 1.2
Pope, 2008	Num: # of men HIV-tested in study period Denom: # of male patients	18.6 (36/194)	8.4 (20/238)	10.2	OR: 3.7[g] OR: 2.40 (1.05-5.50)[f]	NR
Wanyenze, 2011[p]	Num: # of male patients tested and receiving results Denom: # of male patients offered PITC/voucher	100 (109/109)	64.6 (62/96)	35.4	1.55 (1.34-1.80)[d]	NR
		Community-based Strategies				
Corbett, 2006[h]	Num: # of males accepting on-site VCT/ voucher for off-site VCT in the study period Denom: # of male employees	54.8 (1634/2981)	13.7 (340/2474)	41.1	2.7 (1.8-3.9)[i] 3.99[d]	2.8 (1.8-3.9)[j]
Burnett, 2011	Num: # of males reporting ever-testing post-intervention Denom: # of males with complete data post-intervention	48.4 (15/31)	6.5 (2/31)	41.9	7.50 (1.87-30.08)[d]	OR: 10.96 (4.59-26.15)[k]
Sweat, 2011 (Tanzania)	Num: # of men testing at least once in study period Denom: 50% of target populationl	43.7 (1365/3125)	9.1 (306/3367)	34.6	4.81[d]	NR
Sweat, 2011 (Zimbabwe)	Num: # of men testing at least once in study period Denom: 50% of target population[l]	52.6 (2816/5350)	5.3 (323/6075)	47.3	9.90[d]	NR
Lugada, 2010	Num: # of male HH members tested in study period Denom: # of male HH members aged ≥15 years	45.1 (427/947)	9.1 (44/484)	36	4.96 (3.71-6.63)[d]	10.4 (7.89-13.73)[m]

Doherty, 2013	Num: # of men testing during study period Denom: # of men surveyed in post-intervention household survey	47.3 (229/484)	32.7 (189/578)	14.6	PR: 1.52 (1.19-1.95)	NR
Fylkesnes, 2013	Num: # of men testing in year prior to the follow-up survey Denom: # of men surveyed baseline & follow-up	76.1(N=255)	42.2 (N=261)	33.9	1.8 (1.4-2.3)	NR
Low, 2013[n]	Num: # of men reporting ever testing Denom: # of men surveyed in post-intervention household survey	92.7 (580/626)	53.6 (351/655)	39.1	1.73[d]	NR

ANC, antenatal care; CI, confidence interval; HH, household; HTC, HIV testing and counselling; NR, not reported; OR, odds ratio; PR, prevalence ratio; RR, risk ratio.

[a]Per-protocol analysis: intervention 95.3% (82/86) and control 90.7% (68/75); OR adjusted for male partner's age, occupation and education level.

[b]OR based on combined indicator of logbook and women's self-report of men's HTC. Adjusted for age, female remunerated activity, partner alcohol consumption, HIV status, whether women reports partner ever tested, ever discussed condom with partner, women suggested HIV-testing to partner.

[c]Adjusted for women's age, marital status, religion and cohabitation.

[d]RR calculated using Epi-Info.

[e]OR for individuals retained at follow-up (HTC at 1 month: 47% versus 28%; HTC before 3-month follow-up: 38% versus 33%) Adjusted for age, race, sex, years of education and baseline testing rates.

[f]OR calculated using STATA.

[g]Reported OR for men and women.

[h]Data for males provided through personal communication (Corbett, 2013).

[i]RR for unadjusted mean uptake of voucher versus on-site VCT by men and women.

[j]Ratio of observed/expected proportions, adjusted for age, sex, marital status, education, household contact with TB patient, self-rated health and strata (high–low absenteeism). Adjusted RR for use of voucher versus on-site VCT by men and women 12.5 (8.2–16.8)

[k]Data for males provided through personal communication, 2014. OR of change in ever had HIV-test from pre to post-intervention, excluding those who tested pre-intervention.

[l]Calculated by assuming that 50% of the target population was male.

[m]Adjusted for age and sex.

[n]Data available in paper; however, data for men aged at least 15 years provided through personal communication (Low, 2014).

[o]Data for men provided through personal communication (Brown 2013) [p]Data for men provided through personal communication (Wanyenze 2012)

2.8 Chapter Summary

The priority placed on implementing PITC in ANC was warranted in light of women's increased biological and social vulnerability to HIV and the success of anti-retrovirals in PMTCT (72). However, the absence of a similar focus on men has resulted in marked gender disparities in access to HTC, treatment and care services (43, 72, 104). An estimated 45% of individuals in sub-Saharan Africa aged 15-49 remain unaware of their HIV-positive status, with men less likely to know their HIV-status compared with women (13, 105).

Strategies that provide HTC services in community settings have emerged to increase levels of HIV-testing uptake (97). These alternatives remove barriers associated with men's access to facility-based services, including distance and location, and are expected to increase men's population-levels of HIV-testing (97). The systematic review found that community-based strategies, in addition to interventions implemented through ANC and PITC in health facility settings, are effective at reaching men (19). Strategies in ANC reach men with a pregnant partner, mobile services reach a high number and proportion of younger men and home-based delivery reaches couples and men with no history of HIV-testing (19, 106-108). Few interventions were targeted specifically at men and some strategies provided HTC services to a low number of men.

Due to their differential reach, the HIV testing strategies identified as effective in the systematic review bear different costs per man HIV tested and per individual newly diagnosed HIV positive (109). PITC reaches a low number of men relative to home-based HIV testing services, and studies have shown that standalone services are more costly than home-based services per person tested (109). However, the cost per individual newly diagnosed HIV positive is lower where services are facility-based, as a higher proportion of those tested are identified as HIV positive relative to community-based service delivery models. Mobile delivery of HIV testing services has proven most costly per person HIV tested and per individual identified as HIV positive yet individuals testing HIV positive through community-based service delivery models are diagnosed at earlier stages of infection (110). There remains, however, little evidence of the cost-effectiveness of different HIV testing strategies and challenges in comparing costs across different strategies

(109). In particular, there is little evidence of the costs and cost-effectiveness of strategies specifically targeted at men.

In 2014, UNAIDS launched the 90-90-90 treatment targets to end HIV by 2030 (109). To achieve knowledge of HIV status among 90% of individuals living with HIV requires a concerted effort to reach men with HTC services through the development and implementation of cost-effective strategies that are appropriate to men. Failure to reach men with HTC, among other HIV-prevention and care services, may undermine the success of existing HIV prevention and control efforts and limit progress in reaching revised UNAIDS treatment targets (43, 72, 104, 109).

Chapter 3. Thesis Rationale and Research Questions

3.1 Thesis Rationale

Available strategies to increase HIV-testing are effective at increasing men's uptake of HIV-testing services (19). Whether these alternative strategies, including couples and mobile HTC, have increased men's levels of HIV-testing at population-level and provided access to men not reached by VCT and other facility-based services warrants investigation (111). Strategies are required that reach men unaware of their HIV-status in support of linkage to treatment and care. Approaches that increase the frequency of HIV-testing among men with an ongoing risk of HIV-infection to provide risk-reduction counselling and linkage to prevention interventions are also required (97). Little is known about men's frequency of HIV-testing in the context of expanded delivery and promotion of HTC services and whether men who test frequently differ from men who opt to test once.

VMMC services are being scaled-up in 14 priority countries in sub-Saharan Africa. Services are delivered through "male-friendly" static and mobile clinics or through outreach in non-facility based settings. Men are offered PITC prior to being circumcised. The scale-up of VMMC services provides an opportunity to increase the proportion of men who know their HIV-status, to provide more men with risk-reduction counselling and, analogous to PITC in ANC, has the potential to "normalise" testing for HIV among men (6). As a consequence, VMMC services may contribute to increasing HIV-testing among all men. The rationale for this hypothesis is described in Section 3.3. In settings where VMMC services have been scaled-up, including Zambia, this hypothesis warrants exploration.

3.2 Thesis Research Questions

In this thesis research I address the following research questions:

1. What strategies to increase HIV-testing are effective at increasing men's levels of HIV-testing in sub-Saharan Africa?

I conducted a systematic review of the published literature to address this question. I presented the manuscript (Research Paper I; Annex 7), published in *AIDS* in 2014, in Chapter 2 (19).

2. In three rural districts in Zambia in 2011-2013, what were the levels of, and factors associated with, men's HIV-testing behaviours? The HIV-testing behaviours explored include:
    a. Ever-testing
    b. Recent-testing
    c. Multiple-testing (2013)
    d. Acceptance of an offer of home-based HIV-testing (2011/12)
    e. Acceptance of an offer of home-based HIV-testing among ever-testers (2013)
3. Did the scale-up of VMMC services contribute to increasing men's levels of HIV-testing in Zambia? If yes, by whom? If no, why not?

To address these research questions, I analysed two repeat population-based surveys conducted in 2011/12 and 2013 in 42 study sites in three contiguous rural districts in Lusaka Province, Zambia (Paper II & IV). Research Paper II (Annex 7) titled *Factors Associated with HIV-Testing and Acceptance of an Offer of Home-Based Testing by Men in Rural Zambia* is published in *AIDS and Behavior* (2014) (26). I submitted Research Paper III, titled *Frequency of HIV-testing and factors associated with multiple lifetime HIV-testing among a rural population of Zambian men* for publication to *BMC Public Health* in 2015 (14). I present additional analyses of these two surveys in Annex 4.

To address research question 3, I conducted an integrated analysis of data from the two population-based surveys, routine monitoring data on the delivery of VMMC services and systematic observations of the promotion of VMMC services in three districts (Research Paper IV). These findings were developed into a manuscript titled *Did the scale-up of voluntary medical male circumcision services contribute to increasing men's population-levels of HIV-testing in Zambia, 2009-2013* to be submitted to *AIDS Care*.

3.3 The Potential for VMMC to Increase Men's Levels of HIV-testing

As highlighted in chapter 2, VMMC services are being scaled-up in 14 priority countries following recommendations from WHO and UNAIDS. The potential role of male circumcision in HIV-prevention first emerged in the 1990s, when ecological studies suggested that male circumcision might protect against HIV-infection (112). Vulnerable to ecological fallacy, observational studies soon followed, yet, concerns remained that studies were at risk of confounding and misclassification of circumcision status (113, 114). In 2007, RCTs in Kenya, South Africa and Uganda confirmed findings from observational studies (20-22), prompting the recommendation from WHO and UNAIDS that Zambia, among other countries, incorporate VMMC into their national HIV-prevention strategies.

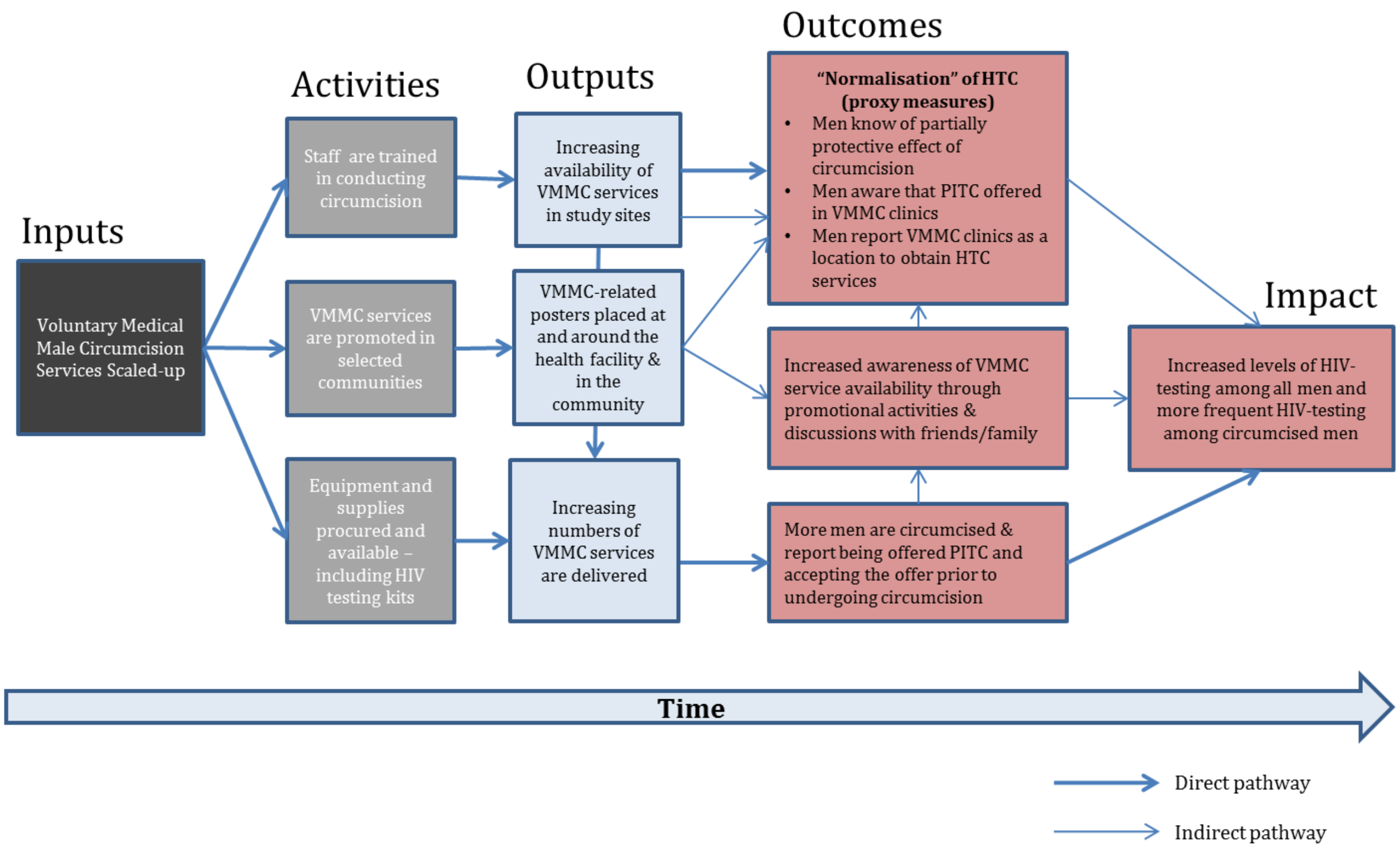
In 2009, the Zambian Ministry of Health formally adopted VMMC as an HIV prevention strategy (115) and in 2012, launched the 2012-2015 Operational Plan for the Scale-up of VMMC Services. This plan highlights two implementation phases, a "catch-up" and "sustainability" phase (116). In the "catch-up" phase the aim is to circumcise 80% of HIV negative men aged 15-49 years by 2015. In 2007, circumcision prevalence in Zambia was 13% (117). As traditional male circumcision is not widely practiced in Zambia, prevalence varied by Province: prevalence in North-Western was 71% compared with 40% in Western and 10% in Lusaka Province (117) (118).

A Communications and Advocacy Strategy (2012-2015) was developed alongside the operational plan, emphasising the need for demand generation (119). The strategy highlights the need for widespread promotion, including "mid-media" community-level promotion through public announcements, posters, and group presentations. Underpinning the strategy is the theory of "Diffusion of Innovations" (119, 120). This theory proposes that acceptance of an innovation is dependent on communication rates through a social groups over time (120). The theory describes characteristics of an innovation that influence its rate of diffusion, including "complexity", and suggests that as more individuals adopt the new technology there will be a "tipping point" at which the majority of the social system will adopt it (120).

Through the offer of PITC, the scale-up of VMMC is likely to have a direct effect on levels of ever-testing for HIV among men opting to be circumcised. The scale-up of services may also have indirect effects on men's HIV-testing. If service availability and promotion increases with time, more men may opt to be circumcised and learn their HIV-status by accepting PITC. Circumcised men may discuss the VMMC process with family/friends, increasing men's awareness of VMMC service availability and that HTC is available in VMMC clinics. Increased promotion of services may also contribute to knowledge of service availability and the offer of PITC prior to circumcision. As such, testing for HIV may be seen as commonplace among men, similar to the effect of PITC among pregnant women in ANC (6, 121). The scale-up of VMMC services may therefore encourage men not opting for circumcision to learn their HIV-status and increase the frequency of HIV-testing among circumcised men.

Figure 4 illustrates the pathways through which the scale-up of VMMC services is hypothesised to contribute to men's levels of HIV-testing. The pathway draws on evidence from a systematic review of mass media interventions to increase HIV-testing, which found that promotion had an immediate effect on HIV-testing (122). Although no studies from developing countries were included in the review, the authors suggest that findings were generalisable to a developing country context (122). Similarly, a meta-analysis of mass media interventions for HIV prevention, which included studies conducted in Africa, found that mass media campaigns, defined as national campaigns to deliver messages through radio, newspaper and printed material, can be effective can increasing condom use and knowledge (123). The proposed pathway also draws on elements considered key to the dissemination of a new technology as highlighted in the Diffusion of Innovations theory (120). In particular, the pathway draws on the "communication channels", including individual-level communication and mass media promotion, through which information and knowledge on an innovation is disseminated through a "social system" (119, 120). The Theory of Planned Behaviour is used to explore whether the promotion of VMMC services influences HIV testing behaviours (124). Knowledge that VMMC services are available and that HIV testing services are offered within VMMC clinics is expected to influence norms around circumcision and HIV testing, and men's attitudes towards testing for HIV. Increased awareness that HIV testing services are offered to men attending VMMC clinics is expected to facilitate perceived control over the act of accessing HIV testing services thereby changing men's intentions to test for HIV and ultimately their HIV testing behaviours (124).

Figure 10. Direct and indirect pathways through which the scale-up of VMMC services might contribute to increasing men's HIV-testing



3.4 Structure of the Thesis

In Chapter 4 I describe the methods used to address the research questions. I provide details of the field research setting and describe data collection processes, study variables and an overview of the data analysis strategy. I end the chapter by describing ethical and ministerial approvals.

In Chapter 5, I describe the study sites, defined as a health facility and its catchment area, including catchment population and distance to a hospital. I describe the availability and promotion of HTC and VMMC services in the study sites.

In Chapter 6, I present details of participation in the population-based surveys, and compare the characteristics of participants to non-participants. I describe characteristics of the households and men consenting to participate in the surveys. I describe and compare levels of HIV-testing in the study area by sex and age, and men's knowledge of measures to prevent HIV-infection and of HTC service availability. I describe the year in which men reported their first HIV-test.

In Chapter 7, I include Research Paper II: *Factors Associated with HIV-Testing and Acceptance of an Offer of Home-Based Testing by Men in Rural Zambia* (26). In Chapter 8, I include Research Paper III: *Frequency of HIV-testing and factors associated with multiple lifetime HIV-testing among a rural population of Zambian men* (14). In Chapter 9, I include Research Paper IV, *Did the scale-up of VMMC services increase men's population-levels of HIV-testing, 2009-2013.*

In Chapters 10, I summarise findings from across the thesis. I highlight the limitations of the research methods and discuss the findings. I synthesise findings from across the thesis to develop a set of recommendations to increase men's levels of HIV-testing and areas that require additional research. In Chapter 11, I include a conclusion to the thesis.

3.5 Authors Role in the Study

This observational study is nested within an unrelated cluster randomized stepped-wedge trial (CRT), the Better Health Outcomes through Mentoring and Assessment (BHOMA) trial. To evaluate the trial, repeat population-based surveys were conducted. The first survey was conducted in 2011/12, the second in 2013. In the 2011/12 survey, the individual questionnaire included a limited number of questions regarding HIV-testing history and no questions on HIV-related knowledge, male circumcision knowledge or status. I designed and added additional HIV-knowledge and HIV-testing related questions and questions pertaining to knowledge of male circumcision and circumcision status to the men's survey. I adapted the HIV-testing questions from the DHS and a questionnaire developed by the World Health Organization available in: *HIV testing, treatment and prevention: generic tools for operational research* (125). I developed the male circumcision questions based on the DHS questionnaires.

The questions were translated into Nyanga, the language predominantly spoken in the study area, and piloted in a pilot BHOMA study site. While refining additions to the men's questionnaires, I tested the personal digital assistants (PDAs) used to collect data to assess whether all additions were correctly programmed, jumps in the programme were functional and any data errors were correctly highlighted by the PDA. I did this for the entire BHOMA survey, including household and women's questionnaires, which had also been amended. I assisted in training the BHOMA research assistants (RAs) on all additions and revisions to the population-based surveys and developed a manual to assist the research teams in completing data collection.

I conducted systematic observations to collect primary data on the promotion of VMMC and HTC services (section 4.2.4). I obtained funding from the *Gordon Smith Travelling Grant* to conduct systematic observations. I developed the observation tool using as a guide a tool used in a study to explore the effect of alcohol advertising on student's alcohol consumption (126). I developed a VMMC services audit, which determined whether adult male circumcision services were offered at the health facility or through mobile/outreach services, who offered the services and since when they had been available. Upon completion of the data collection tools, I trained the RAs hired to conduct the systematic observations and managed the data collection process.

Section 2: Methods

Chapter 4. Methods

The chapter is structured as followed:

Section 4.1 Description of the Field Research Setting

Section 4.2 Data Collection

Section 4.3 Definition of Study Variables

Section 4.4 Data Analysis

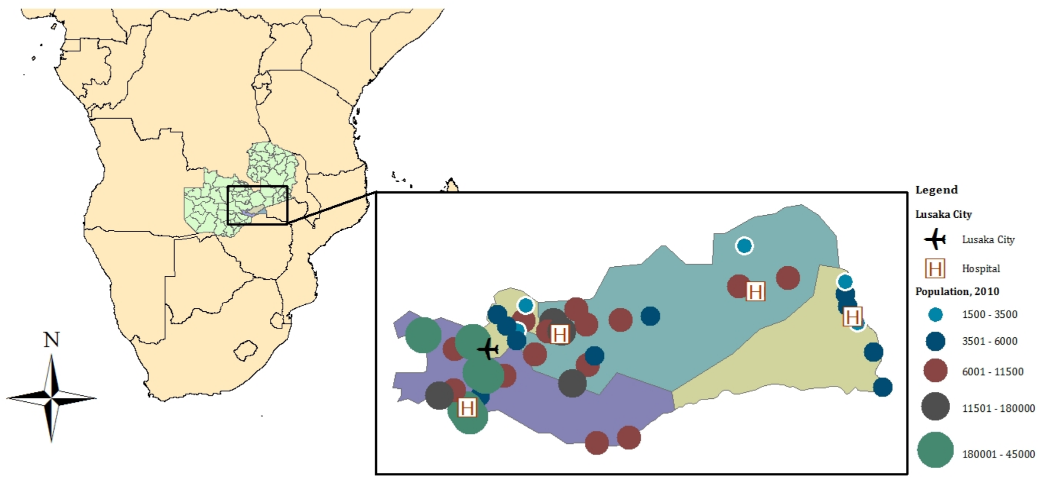
Section 4.5 Ethical Approval

4.1 Description of the Field Research Setting

BHOMA was undertaken in three primarily rural districts of Lusaka Province, Zambia. I provide more detail on the BHOMA intervention in Annex 1. Zambia is a landlocked, predominantly rural, country in Southern Africa (Figure 11). In the 2010 Census of Population and Housing, Zambia had a population of approximately 13 million (127). An estimated 15% resided in Lusaka Province and 65% in rural areas (127). Almost 50% of the population were estimated to be aged less than 15 years (127).

In the last decade, Zambia experienced rapid economic growth (128), attributable in part to the copper mining industry. Nonetheless, roughly 60% of the population live below the poverty line. Primary school completion rates in 2009 were high at 93%. An estimated 56% of students completing primary education enrol into secondary education (129). In addition to high levels of poverty, Zambia continues to face public health challenges, primarily communicable diseases, including malaria, HIV/AIDS, tuberculosis (TB), but also non-communicable diseases (129-131).

Figure 11. Map of Zambia and of the 42 study sites in three districts of Lusaka Province, Zambia, with their estimated population (2010)



Health services in Zambia are delivered through publicly-run health facilities and available through private-for profit and non-profit organisations, including faith-based institutions. Public services are divided into five tiers: the third-, second- and first-tier facilities are hospitals, which provide services such as diagnosis and surgery at district- through to national-level. Facilities in the fourth tier are community-based services defined as urban or rural health centres with tier five defined as health posts, which serve remote communities with limited access to health centres.

According to the National Health Strategic Plan 2011-2015, health centres should be equipped to provide maternal, newborn and child health services, malaria prevention and control interventions, HIV-prevention services, including male circumcision, condom distribution and PMTCT, ART, and the implementation of comprehensive health promotion strategies among other services (129). Urban health centres serve catchment populations of between 30,000-50,000 people and rural health centres serve populations of approximately 10,000 people. Although health centres should be staffed with a minimum of two healthcare professionals, in 2009, an estimated 47% of health centres in Zambia were adequately staffed (129).

Historically, Lusaka Province was divided into four districts: Lusaka, Chongwe, Luangwa and Kafue. At the time of analysis and writing, the government divided Chongwe and Kafue districts, creating two additional districts called Rufunsa and Chilanga.

In the 2010 National Census, Lusaka Province had a population of roughly 2.2 million people (127). Up from 1.4 million in 2000, the province experienced an annual growth rate of 4.9%. In 2010, 80% of the population resided in Lusaka district, with 20% (n=444,073) residing in the remaining three districts (51% in Kafue, 43% in Chongwe and 6% in Luangwa). The dominant languages are Nyanga and Bemba. Zambia's official religion is Christianity.

Levels of poverty in Lusaka Province are lower than the national average due to a growing middle class based primarily in Lusaka city (132). Poverty, measured as the proportion of individuals living on less than $1 a day, declined from 25% in 2006 to 24% in 2010 (133). Participation in the labour market was 73%, with 66% of employed individuals relying on informal employment and an estimated 9% of males unemployed compared with 13% of females (133).

This study was conducted in 42 study sites, defined as a health facility and its catchment area, in Chongwe, Kafue and Luangwa (Figure 11). The districts have 48 public health facilities, however, six were randomly selected to be pilot sites and excluded from the BHOMA evaluation. The majority of health facilities in the study are rural tier-four health centres. Kafue and Chongwe districts had at least one Zambian National Services (ZNS) health facility each and a district-level hospital. District-run hospitals and ZNS health facilities were excluded from BHOMA.

Chongwe district lies just east of Lusaka city along the Great East Road, which links Lusaka to Eastern Province. The Zambian Central Statistics Office (CSO) classifies 96% of Chongwe as rural (134). Population growth between 2000 and 2010 was 3.4%. Residents rely primarily on agricultural activities for their livelihoods. Chongwe district is geographically the largest of the three districts. Other than Chongwe town, the district capital, there are few peri-urban sites. Chongwe district has 25 health centres, three health posts, a district hospital and a health centre linked to a mission-supported hospital.

Kafue district lies to the south of Lusaka district. It is the most urbanised of the three districts, with the CSO classifying 69% of residents as rural (134). Population growth between 2000 and 2010 was 4.2%. The district has 14 health centre and two health posts. The majority of the study sites lie along a highway linking Lusaka to Livingstone. Livelihood options include work at a large cement factory along the highway, agricultural activities, fishing, and the tourism industry in two sites near the Kafue River.

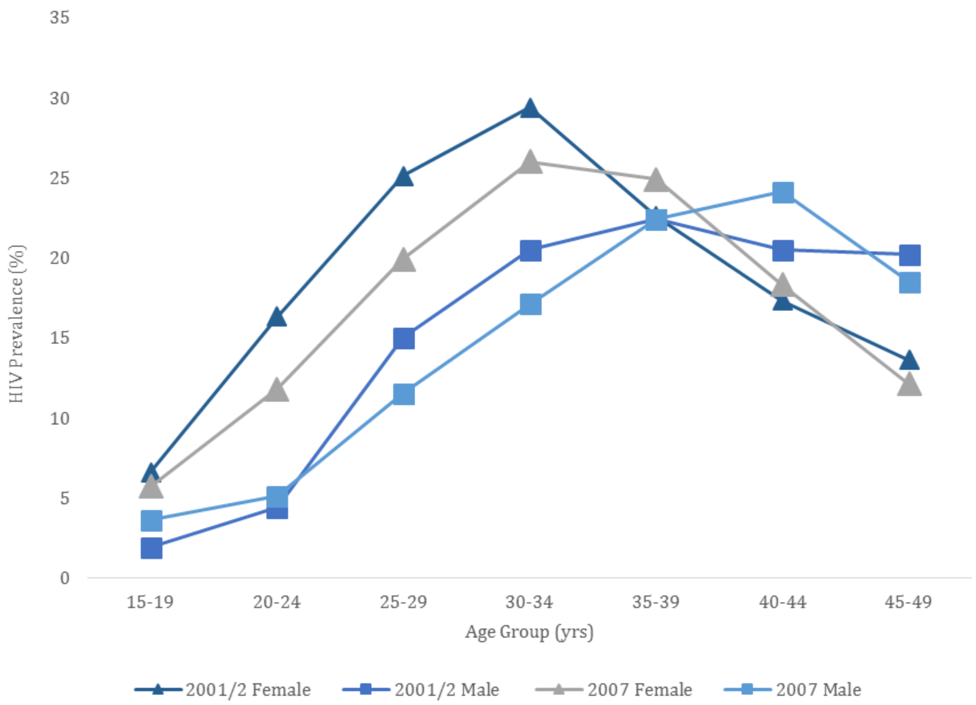
Luangwa district is the least populated of the three districts. The CSO classifies 86% of Luangwa residents as rural (134). The district borders Zimbabwe and Mozambique, and lies along the Zambezi and Luangwa rivers. Of the three study districts, it has the poorest health outcomes, including infant mortality. The district has eight government run health facilities and a mission facility supported by the Churches Health Association of Zambia (CHAZ). In addition, there are 26 health care posts run by volunteers and used for outreach services by the health facilities.

4.1.1 History of the Zambian HIV Epidemic and Delivery of HTC Services

The first diagnosis of an AIDS case was in 1984. HIV prevalence rose through to the mid-1990s and peaked at around 16% in 2001/2 (117, 135). In 2002, the Zambian government established the National HIV/AIDS/TB/STI Council to coordinate the national response to HIV (136). In 2004, with unprecedented levels of AIDS-related mortality and increasing incidence, the government declared HIV a national emergency.

In the last decade, HIV prevalence has remained relatively stable (136). In the 2007 DHS, HIV prevalence was estimated at 14% (Figure 12) (117, 135). As in other countries in the region, HIV prevalence was higher among women (16%) than men (12%) (117). HIV prevalence peaked at 24% among men in the 40-44 year age group and at 26% among women in the 30-34 year age group (Figure 12) (117). In Lusaka Province, the prevalence was 22% among women and 19% among men (117). Prevalence among men in urban areas was 16% compared to 9% in rural areas (117). In 2009, with an estimated 226 adults newly infected per day, HIV incidence was estimated at 1.6% (2% among females; 1.2% among males), half the incidence estimated in 1990 (136).

Figure 12. HIV Prevalence by age and sex in Zambia, 2001/2 & 2007



Source: Adapted from 2007 Zambian DHS (117)

In 1999, Zambia initiated VCT service delivery in 21 pilot sites (137). By 2006, the number of VCT sites increased to 485 and guidelines highlighted the need to recommend routine PITC for pregnant women, individuals attending STI clinics and in facilities where HIV is prevalent and ART available (137). The National HIV and AIDS Strategic Framework (2006-2010) (NASF) highlighted plans to introduce mobile VCT services (138). The 2011-2015 NASF reiterated plans to strengthen mobile HTC services and the scale-up couples HTC was listed as a core component of the HTC strategy (139). The NASF target was 30% uptake of HIV-testing and receipt of the result of an HIV-test in the previous 12 months among individuals aged 15-49 years by 2013, increasing to 50% by 2015 (139).

4.2 Data Collection

The data sources I use are: i). Two population-based surveys; ii). Health facility audit data; iii). Routinely collected data on the delivery of VMMC services by Society for Family Health (SFH) and iv). Primary data collected through systematic observation in all study sites.

4.2.1 The BHOMA Population-based Surveys (i)

The population-based surveys comprised household enumeration forms, a household questionnaire, individual questionnaire and health measurements, including the offer of rapid HIV-testing (Determine™ HIV-1/2) upon completion of the individual questionnaire (130). The questionnaires were adapted from DHS. The primary aim of BHOMA was to reduce adult all cause and under-5 mortality (130). Increasing HIV-testing was not an outcome of BHOMA (26). The 2011/12 survey was conducted from May 2011 to February 2012 and the 2013 survey from February to November 2013.

4.2.1.1 Sampling

The study population was households and individuals aged 15-59 years residing within a 3.8 kilometre (km) radius of the health facility to minimise contamination (130, 140). The radius of each health facility was divided into $900m^2$ squares containing between five and 50 households. Squares were randomly selected and assigned a random number between one and 30. Computer-generated randomization was used to determine which squares would be visited and the order of visitation (26, 130). All households within randomly selected squares were eligible for participation in the survey (130). In the 2011/12 survey, 120 households were enumerated in each study site. After visiting the first household in a square, all households were visited even if the target number had been enumerated (26, 130).

The sample size for the 2013 survey was increased to 300 households as the estimated mortality in the 2011/12 survey was lower than the predicted mortality used to estimate the required sample size. Of these households, 120 were invited to participate in a *full* survey, which included all household and individual questionnaires, and 180 were invited to participate in a *partial* survey, in which the household head was asked to complete a household enumeration form and the household questionnaire (14). The PDAs informed research teams whether to offer the next household a full or partial survey prior to the household visit. Surveys were offered in a systematically random manner, with every 2.5^{th} household offered the full survey (40% offered the full survey)(14).

4.2.1.2 Inclusion and Exclusion Criteria

A household was defined as a group of people who ate and slept in the same residence and identified a common head of household. Household members were defined as individuals who were present at the time of the household visit and who spent the previous night at the household. Individuals who were absent but had spent the previous night at the household were also enumerated as were individuals who spent a minimum of 14 days in the household at any point in the recall period. In the 2011/12 survey, the recall period was the 12 months preceding the survey. In the 2013 survey, the recall period was 24 months preceding the survey.

Individuals were eligible to participate in the individual questionnaire if they were aged 15 to 59 years and were able to provide informed consent (130). For individuals aged 15-17 years, consent was also obtained from a parent or guardian. Individuals with mental or other disabilities who were unable to provide informed consent were excluded. For research presented in this thesis, analyses were restricted to men.

4.2.1.3 Data Collection

Household heads were asked whether the household consents to participate in the evaluation. Consenting household heads completed the household questionnaire and enumeration form. The questionnaire included questions pertaining to household assets and housing material. The enumeration form collected information on household members, including age, sex, whether the member was a household head and whether they were absent, present or had died for each month in the recall period (Annex 2).

Eligible individuals were asked for their consent to participate in individual questionnaires. Individual questionnaires collected demographic data and data on self-reported health, including whether the individual had been diagnosed with diabetes, epilepsy, TB or a psychiatric illness. Women were asked about their birth history. After completing the individual questionnaire, individuals were offered rapid HIV-testing.

If households were absent at the time of the first visit, up to three repeat visits on different days were conducted. Repeat visits were not conducted if an enumerated individual was absent at the time of the household visit as BHOMA's primary outcome was obtained from enumeration forms.

4.2.2 BHOMA Health Facility Audit (ii)

The health facility audit included questions on service provision, the availability of essential medicines, including ART, and diagnostic equipment, including HIV-testing kits (141, 142). The audit was based on tools developed by WHO, MEASURE Evaluation Facility Surveys and Health Facility Assessment Network (141, 142). The first audit was conducted from January to February 2011; the second audit in May 2012 (141, 142). The in-charge at each of the 42 health facilities completed the audit. Each facility was visited once to complete the health facility audit.

4.2.3 Society for Family Health Monitoring Data (iii)

I was provided with data from SFH on where in the study area VMMC services were delivered and the number of circumcisions performed on all males and men aged 15 years or older from January 2009 through December 2013.

4.2.4 Systematic Observation (iv)

I conducted systematic observations in the 42 study sites to collect data on HTC promotion and the availability and promotion of VMMC services. The systematic observations collected data on the promotion of VMMC services through posters, billboards and community sensitization activities, including drama, health talks and mobile video units. The systematic observations focused primarily on posters. My rationale for this was based on the National VMMC Communication and Advocacy Strategy (2012-2015) (118), which emphasises the use of "mid-media" (posters, drama, public announcements) to promote services at community-level. Furthermore, as the observations were cross-sectional, I assumed that posters were more likely to be observed than dramas, public announcement or other one-off, temporary activities. Alongside observations, an audit on VMMC service availability was completed with the in-charge of each facility.

4.2.4.1 Sampling

All 42 study sites were visited. I used Google Earth™ to demarcate the areas where systematic observations would be conducted. The first site for observation was the health facility and a 1.5km radius of the facility. I selected this radius, as for most sites, the villages, schools and other areas where promotion was likely to occur, were concentrated within this radius.

To increase generalisability of the findings to the evaluation area, I randomly selected two "high density" areas outside the 1.5km radius but within the 3.8km radius. I defined high density areas as 900m^2 squares containing at least a school, church, village/compound, work sites or market. I chose these landmarks as they were areas where a higher concentration of men were likely to be found and therefore likely to be targeted for VMMC and HTC promotion. Using Excel™ I randomly generated two numbers to determine which high-density areas were to be included in the systematic observations. For sites with two or less high density areas I selected all areas.

Stratifying by district, I determined the order of study site visitation using computer generated random numbers. For logistical and financial reasons, I started the observations in Chongwe district followed by Kafue and Luangwa. Two teams of two RAs conducted the systematic observations. The RAs were sixth/seventh year medical students from the University of Zambia Medical School.

4.2.4.2 Inclusion and Exclusion Criteria

Any poster or billboard, including those that were hand written, developed on a computer, painted on a wall or stickers/leaflets displayed as posters, were considered eligible for documentation if their content related to VMMC, HTC or HIV prevention. HIV prevention, defined as the promotion of an intervention to prevent HIV transmission, including condoms, counselling, abstinence, was included to ensure all relevant posters and leaflets were captured. Posters promoting adherence to ART or anti-stigma messages were not eligible for inclusion, unless the ART poster discussed the prevention benefits of ART. The same criteria was applied for other promotional activities observed.

4.2.4.3 Data Collection

The systematic observations were conducted once in each site. Observations started at the health facility. Upon arrival at the facility, the RAs obtained consent from the in-charge. One RA completed the VMMC audit while the second started the observations within and around the health facility.

At the health facility, RAs documented and photographed eligible posters and other activities in and around the facility. In peri-urban sites, upon completion of observations at the health facility, RAs took a spiral walk within the 1.5km radius around the health facility. In rural sites, areas of higher density within the 1.5km radius were visited.

The RAs visited the two high density sites within the 3.8km radius after completing data collection in the 1.5km radius. As in the 1.5km radius, RAs photographed any promotional materials or activities and took GPS coordinates.

4.2.5 Data Management and Cleaning

Data collected through the population-based surveys were stored on a PDA and sent to ZAMBART in Lusaka on a weekly basis. The health facility audit was collected using paper-based forms. Data were double-entered centrally by the ZAMBART data teams. Data was kept centrally until completion of data collection in all study sites.

For the analysis of men's HIV-testing behaviours that form part of this thesis, I cleaned the data and linked men to their spouse using a unique household ID and household member number as listed on the household enumeration form. As the PDA was programmed with skips, jumps and warning messages where data entry errors occurred, little cleaning of the individual questionnaire data was required at the analysis stage. I entered and maintained the data from the systematic observation and VMMC audit in Excel™.

4.3 Description of Study Variables

4.3.1 HIV-Testing

The outcomes of interest throughout this thesis were men's self-reported HIV-testing behaviours, including: ever-testing, recent-testing, and multiple-testing, and the acceptance of an offer of rapid home-based HIV-testing (Table 4). I defined ever-testing as reporting ever-testing for HIV in the 2011/12 survey. In the 2013 survey, I used additional data available on men's HIV-testing behaviours to restrict this definition to men who reported ever-testing and receiving the result of an HIV-test. I opted to restrict the definition of ever-testing in 2013 as men who did not obtain the result of their HIV test would not be aware of their HIV status. With rapid-testing widely available, few men (n=40; 3% Research Paper III) reported never receiving the result of an HIV test.

To describe population-levels of recent HIV-testing I use all men as the denominator. To explore factors associated with recent-testing, I removed from the denominator men reporting themselves as living with HIV whose most recent test was >1 year ago (2011/12 survey) or who reported being diagnosed >1 year ago (2013 survey).

I derived the variable "acceptance of an offer of home-based HIV-testing" from results of the rapid HIV-testing offered upon completion of the individual survey. Where the result was positive or negative I defined men as accepting the offer of home-based testing. Where a result was missing this indicated that the individual had not been tested for HIV.

Table 4. Definition and measurement of the HIV-testing outcomes used in the analyses of the 2011/12 and 2013 surveys

Outcome	Definition	Question in survey	Numerator	Denominator	Exclusions
Ever-HIV-tested (2011/12 survey)	Whether men reported ever having tested for HIV	Have you ever been tested for HIV?	Men who responded Yes	All men with no missing data on ever HIV-testing question	-
Ever HIV-tested (2013 survey)	Whether men reported ever having tested for HIV & receiving the result of an HIV-test	Have you ever been tested for HIV? Have you ever had the results of an HIV test?	Men who responded Yes to both questions	All men with no missing data on ever HIV-testing question	-
Recently HIV-tested	Whether men reported an HIV-test within the year before the survey	How many years ago did you LAST test for HIV? How many years ago did you FIRST test for HIV? (2013 survey only)	Men who responded that they had had any HIV-test <1 year ago	All men with no missing data on ever HIV-testing question and no missing data for both dates of HIV-tests	In 2011/12: men who reported themselves HIV-positive & their last HIV-test >1yr ago In 2013: men who reported learning of their HIV-positive status >1yr ago
Multiple HIV-tests (2013 survey)	Men who reported more than one lifetime HIV-test	How many times have you had an HIV test?	Men who reported >1 lifetime HIV-test	<u>Among ever HIV-tested</u>: All men who ever-tested for HIV <u>Among entire sample population:</u> all men with no missing data for HIV-testing question	Men who reported that their HIV-positive diagnosis preceded any multiple HIV-testing (ie. men diagnosed HIV-positive at their first HIV-test)
Acceptance of an offer of home-based HIV-testing	Whether men accepted the offer of rapid HIV-testing after completion of the individual survey	Not based on a question but on whether men had a result for the rapid Determine HIV-1/2™ test	Men with no missing data on result of rapid HIV-test	<u>Among entire sample population</u>: all men with no missing data on variables of interest <u>Among ever HIV-tested</u>: All men who ever-tested for HIV	-

4.3.2 Independent Variables

In Table 2, I present the independent variables explored for their association with HIV-testing outcomes and/or with participation in the individual-survey. I derived most independent variables from the population-based surveys (Table 5).

Individual-level variables explored for their association with HIV-testing included age, level of completed education, religion, marital status, and whether men were on or had ever been on TB-treatment. In the 2011/12 survey, I categorised education as none, primary, secondary or higher. As few men reported no education, I categorised men as having either no/primary, incomplete secondary or complete secondary/higher education in the 2013 survey. Similarly, few men were divorced or widowed in the 2013 survey. I created an "ever married" category, which combined men who were separated, widowed or divorced. In the 2011/12 survey, few men reported any form of employment (~25%). I decided not to use this variable as the question was likely misinterpreted to mean formal employment only. The question was rephrased in the 2013 survey and I explored its association with HIV-testing outcomes. For men linked to a spouse who completed an individual questionnaire, I explored whether ever-testing for HIV, having children or current pregnancy were associated with outcomes.

I estimated whether men were circumcised since the scale-up of VMMC services (between 2009 and 2013) by creating a binary variable from information on current age, reported age at circumcision and date of the survey. I used the same data to estimate whether men were recently circumcised, defined as being circumcised in the year preceding the survey. Men who were estimated to have been circumcised within 1.5 years of the survey were defined as recently circumcised to account for possible errors in recalling age at circumcision.

I estimated household SEP quintiles using principal components analysis (PCA). I present details of this analyses in Annex 3. I estimated HIV-prevalence of study sites using the results from the rapid HIV-testing offered after completion of the individual questionnaire. I created a second HIV-prevalence variable based on men's self-reported HIV status to explore whether estimates of association with ever-testing were sensitive to the measure used. I developed a binary variable of >10% or <10% for HIV prevalence. I defined this cut-off as a systematic review of home-based HIV-testing found that uptake of home-based testing was higher in settings where HIV-prevalence was <10% (102).

In the 2013 survey, I explored additional factors using the questions added to the men's questionnaire, including individual-level employment, and community-level employment and knowledge of HIV, which were associated with ever-testing among married men in an analysis of the 2001/2 Zambian DHS (143). I developed a variable for community-level characteristics by aggregating individual-level data. I developed a binary variable for whether >25% of men knew three or more ways to prevent HIV using individual responses to an HIV-knowledge question. I chose this cut-off as it split sites into roughly two equal groups. For cluster-level employment, I developed a binary variable for whether more than half the men reported being employed.

I obtained variables used to describe and compare participating to non-participating men from the household enumeration form, including the size of men's household and whether men were listed as a household head.

Descriptive statistics in Chapter 5 to describe the study sites include the estimated catchment population and distance to a hospital. I estimated the 2013 catchment population of each facility using the 2010 estimates provided to ZAMBART by the Ministry of Health and the annual district-level growth rate reported in the 2010 Census of Population and Housing (127). I estimated the population of men (defined as aged 15 years or older in this thesis) using the district-level sex distribution reported in the 2010 Census (Chongwe 50.3%; Kafue 50.1% and Luangwa 49.3%) and the proportion of the population that were adults males in the 2007 Zambian DHS (117, 127, 134). Using data from the 2011 and 2012 health facility audit, I describe the capacity of the health facilities to deliver HTC services. I use data from the systematic observations to describe HTC promotion. I describe where VMMC services were available using VMMC service audit data and SFH monitoring data. I describe where in the study area VMMC services were promoted using systematic observation data.

Table 5. Description of the independent variables, their source and coding used in analyses to explore the factors associated with HIV-testing outcomes and with participation in the individual survey

	Source	Original Question	Original Response Options	Coding used in Analyses
Individual-level Characteristics				
Age	Individual Survey	How old were you at your last birthday?	Numerical response	15-19; 20-29; 30-39; ≥40
Education	Individual Survey	What is the highest level of education you have attained?	No education; Grade 1-12; College; University; Don't know/refuse	None; Primary (combined in 2013); Secondary or higher (incomplete secondary in 2013); Complete secondary/higher (2013 only)
Household Head (2013 survey only)	Household enumeration	Whether men were listed as a household head	No; Yes	No; Yes
Occupation (2013 survey only)	Individual survey	Are you doing any daily activity to earn money or get food? If Yes, What is your workplace?	No or Yes AND Office; Field worker; Bar; Shop; Own land; Someone's else land; Street; Business person; Don't know/Refuse	None; Agricultural (others land); Agricultural (own land); Professional/services
Religion	Individual survey	What is your religion/denomination?	Protestant; Catholic; SDA; Other; Muslim; None; Don't know/Refuse	Protestant; Catholic; SDA (Seventh Day Adventist); Other; None
Marital Status	Individual survey	What is your current marital status?	Single; Married; Separated; Divorced; Widowed; Cohabiting; Don't know/Refuse	Single; Married/Cohabiting; Separated/divorced (ever married – 2013 only); Widowed (2011/12 only)
HIV Status	Individual survey	Are you willing to disclose your HIV status? What is your HIV status?	Negative; Positive; Refuse/missing	Negative; Positive
History of TB Treatment	Individual survey	Are you currently on TB treatment? Have you ever been on TB treatment before?	No; Yes; Don't know/refuse	No (both questions answered No) Yes (either one or both questions answered Yes)
Circumcised between 2009 and 2013	Individual survey	Are you circumcised? At what age were you circumcised?	No; Yes; Don't know/refuse & Age at circumcision	No Yes

Recently circumcised (within year preceding the 2013 survey)	Individual survey	Are you circumcised? At what age were you circumcised?	No; Yes; Don't know/refuse & Age at circumcision	No Yes
Couple-level Characteristics				
Wife currently pregnant	Individual survey	Females asked: Are you currently pregnant?	No; Yes; Don't know/refuse	No Yes
Wife reports having one or more children	Individual survey	Females asked about birth history and: How many sons/daughters are alive but do not live with you? How many son/daughters live with you?	Numerical response	No Yes
Wife ever-tested	Individual Survey	Have you ever been tested for HIV?	No; Yes; Don't know/refuse	No Yes
Household-level Characteristics				
Household SEP	Household survey	PCA using asset ownership and housing material data (See Annex 3)		1 – Lowest; 2 – Low; 3 – Middle; 4 – High; 5 - Highest
Cluster-level Characteristics & District of Residence				
HIV Prevalence (1)	Measurements database – offer of HIV-testing	Individuals offered rapid HIV-testing	Accepted HIV-testing and either HIV+ or HIV- Missing data if individual did not accept testing	<10% >10% as estimated from rapid HIV test
HIV Prevalence (2) - to test sensitivity of HIV Prevalence as measured in (1)	See HIV-status variable above			<10%; >10%
Knowledge of HIV prevention (2013 survey only)	Individual Survey	Proportion of men reporting at least 3 prevention measures at cluster-level	Men asked about various possible measures to prevent HIV-infection	<25% mention three; >25% mention three
Employment (2013 survey only)	Individual Survey	Proportion of men reporting some form of income generating activity	See individual-level employment	<50% employed; >50% employed
ART available at the Health Facility	Health facility audit	Interviewer observes whether ART is available on the day of the audit	No valid unit present Present with at least one unit with valid date of expiration	No valid unit present Present with at least one unit with valid date of expiration
District	Household Survey	Derived from unique household ID		Kafue; Chongwe; Luangwa
Variables Available on Non-participants and explored for their association with participation				
Age	Household	Age category of household member	15-24; 25-59	15-24; 25-59

	Enumeration			
Head of Household	See above			
Present consecutively in previous 6mth	Household Enumeration	Whether member present for each month in recall period	No; Yes	No; Yes
Household SEP	Household survey	PCA using asset ownership and housing material data (See Annex 3)		
Household Size	Household Enumeration	Total number of listed household members	Sum of household members listed in enumeration form	1-25
Urban Cluster	Household Survey	Cluster-level ID used to create variable denoting urban or rural sites		
District	See above			
Time of Survey	Household Survey	Derived from time and date of survey variable	N/A	Morning (630-12); Afternoon (12-16); Late pm (16-1830)
Day of Survey	Household Survey	Derived from time and date of survey variable	N/A	Mon-Thurs; Friday; Saturday-Sunday
Season of Survey	Household Survey	Derived from time and date of survey variable	N/A	Rainy (Dec-Apr); Cool/dry(May-Aug); Hot (Sept-Nov)

4.4 Data Analysis

4.4.1 Description of the Study Sites

In Chapter 5, I describe the study sites, including the availability and promotion of HTC and VMMC services. I describe the capacity of health facilities to deliver HTC services and use systematic observation data to describe the promotion of HTC in the study sites. I describe the number of posters observed and the proportion that promoted HTC. I describe the proportion promoting HTC to men and promoting couples HTC.

I describe whether VMMC services were available at the health facility or through outreach in the catchment area. I describe the organisation that delivered VMMC services and the frequency of service availability. I describe the number of study sites where SFH delivered VMMC services from 2009 to 2013 and the number of circumcisions reported. I describe the promotion of VMMC services in the study sites using systematic observation data.

4.4.2 Participation in the Population-Based Surveys and Characteristics of Participating Households and Men

In Chapter 6, I describe the response rates to the population-based surveys. I present the number of men enumerated and the proportion of men participating and not participating due either to absenteeism or refusal. I compare participating men to non-participants using random effects logistic regression models to adjust for clustering by study site. I ran models for participation separately for the 2011/12 and the 2013 surveys. I estimated the association between variables available for non-participants and participation in the survey, including household SEP, urban residence and district. I restricted the description of characteristics and estimation of factors associated with participation to men with no missing data and who were present in the household in the month preceding the survey, as it was unlikely that men who listed as absent in the month preceding the survey would be survey participants.

Finally, I describe the characteristics of the participating households and men, including their age, levels of education and religion. I describe men's HIV-testing outcomes, including ever- and recent-testing and compare these outcomes to women's and by age. I describe men's knowledge of HTC service availability, reasons for men's most recent HIV-test or for not testing among never-testers, and the frequency distribution of the year in which men reported their first HIV-test.

4.4.3 Factors Associated with Men's HIV-testing Behaviours (Research Paper II & III)

In Chapter 7, I include Research Paper II published in *AIDS and Behaviour* (Annex 7) (26), which describes men's levels of ever- and recent-testing, and acceptance of an offer of home-based HIV-testing and estimates the association between independent variables of interest and these outcomes in 2011/12 (26). The manuscript describes and compares participation in the survey among all men, whether or not they were present in the month preceding the survey.

In Chapter 8, I include Research Paper III of this thesis, which explores men's frequency of testing for HIV and the factors associated with reporting multiple HIV-tests. The manuscript was submitted for publication to *BMC Public Health* in April 2015 (14). I conducted further analyses to estimate the association between the independent variables of interest and: ever-testing in 2013, recent-testing relative to ever-testers who did not report a recent-test in 2013, and factors associated with the acceptance of home-based HIV-testing among men with no history of testing for HIV in 2011/12 and 2013 (Annex 4).

4.4.3.1 Statistical Analysis Framework: Crude and Adjusted Models

To estimate the association between independent variables and HIV-testing outcomes, I used random effects logistic regression models to adjust for clustering by study site. Details of the analyses for each Research Paper are presented in the manuscripts (14, 26). Briefly, I first describe the distribution of independent variables of interest among the sampled population of men and the distribution of the HIV-testing outcomes by these variables. To obtain an estimate of association, I first estimated a crude association between the independent variable and the outcome. For some outcomes, the crude estimate was adjusted for *a priori* considered confounders, including age for ever-testing in 2011/12, and age, district and urban residence in the 2013 survey.

I adjusted crude associations for potential confounders after data exploration. That is, I adjusted for variables associated with the outcome at the $p \leq 0.1$ level in crude models. To avoid over-adjustment, I did not adjust for variables assumed to lie on the causal pathway between the independent variable of interest and the outcome. In the 2011/12 survey, I included a fixed effect for district in adjusted models. In the 2013 survey, I included a continuous variable for population size to adjust for variation in the size of the study sites.

In the 2011/12 survey and for ever-testing in 2013, I explored whether there was evidence that the effect of SEP on HIV-testing outcomes was modified by district. As there was little evidence of interaction, and considering that the power of a test for interaction was likely low, I opted not to test for interaction in analyses of recent- or multiple HIV-testing in the 2013 survey. In both surveys, I explored whether the association between the estimated HIV prevalence and ever-testing for HIV was sensitive to the use of self-reported HIV status. As findings were similar with both measures, I opted to use only the rapid HIV-test results in analyses of recent- and multiple-testing outcomes.

To avoid issues of multicollinearity, I explored whether variables were correlated and whether including both variables in the model led to extremely wide 95%CI for the correlated variables. If there was evidence of multicollinearity, I removed one of the variables from the final model though I found little evidence for multicollinearity.

As outcomes were common, I used marginal standardization to estimate prevalence ratios (PRs) using the *margins* command in Stata, which predicts the probability of the outcome by strata of a variable conditional on variables included in the model. I used the delta method to estimate 95% confidence intervals (95%CI) (*nlcom* command) (144). Random effects logistic regression combines a binomial distribution within clusters with a normal distribution between clusters (140). Parameter estimates obtained from a random effects model may be unreliable, particularly where the intra-cluster correlation coefficient (ICC) is high (>0.25) or the number of observations in a cluster is high (>20). To check the reliability of the models I ran the *quadchk* command after each model.

4.4.3.2 Approach to Missing Data

More than half of the men eligible to participate in the individual surveys were not present at the time of the household visit or refused to participate. With high non-response, there was a high level of missing data for men. Methods to deal with missing data include complete case analyses, or multiple imputation and inverse probability weighting. These methods either assume that data are missing completely at random or missing at random given the data available on non-participants, respectively. I assumed that data in this study could be missing *not* at random, which assumes that conditional on the data available for non-participants, there remain unobserved factors associated with participation and HIV-testing that would bias the outcome.

To explore this assumption, I first compared the characteristics of participating men to non-participating men. These analyses found that men differed in characteristics associated with HIV-testing and that data were, therefore, not missing completely at random. I used Heckman-type selection modelling to investigate whether there was evidence for unobserved factors affecting participation and HIV-testing. I provide details of this analyses in Annex 5 and Research Paper III. These models suggested that HIV-testing and participation in the survey were independent and that correcting outcomes for non-participation did not change the observed outcomes. I ignored non-participants and conducted analyses using data from men consenting to participate in the individual survey. However, as discussed in Chapter 10, there was little data available on non-participating men, particularly at the individual level. Heckman models model HIV and selection at the individual level (145). In the absence of individual level data on these non-participating men, I had limited ability to model selection into the survey and to predict outcomes among non-participating men. These models therefore need to be interpreted with caution.

Non-response to items in the individual surveys was low. Some 0.1% (n=4) of men in the 2011/12 survey were missing data on ever-testing for HIV. In 2013, 1% (n=27) of men were missing data on ever-testing for HIV. For independent variables, data were missing for less than 3% of individuals for all variables in both surveys. In Chapter 6, I present the distribution of the independent variables ignoring missing data, but present the number of men missing data. As item non-response was low and Heckman-type selection models suggested that data were missing at random conditional on the available data, I estimated the associations between independent variables and outcomes by using complete case analyses. In analyses of the 2013 survey, I further restricted analyses by removing men with any missing data from descriptive statistics.

4.4.4 Did the scale-up of VMMC services contribute to increasing men's population-levels of HIV-testing, 2009-2013 (Research Paper IV)

In Chapter 9, I include Research Paper IV: *Did the scale-up of voluntary medical male circumcision services contribute to increasing men's population-levels of HIV-testing in Zambia, 2009-2013*, which investigates the HIV-testing outcomes of circumcised men and whether the scale-up of VMMC services contributed to increasing population-levels of HIV-testing.

To explore a population-level effect, I defined a site as where VMMC services had been scaled-up if SFH reported delivering any VMMC services in the site or the site was a hospital, as VMMC was available through hospitals. I explored the effect on recent HIV-testing, as I hypothesised that, where VMMC services had been scaled-up, recently circumcised men would report a recent HIV-test; men circumcised in the past would be more likely to retest having experienced the process of PITC and uncircumcised men would be encouraged to test for HIV through the normalisation of knowing ones HIV-status. Therefore, in a given year, a higher proportion of men in study sites where services had been scaled-up would report testing for HIV.

4.4.4.1 Statistical Analysis: Crude and Adjusted Models

VMMC services were not randomly allocated to the study sites. My analyses, therefore, followed a non-randomised study design approach. I used cluster-level summaries to investigate the hypothesised effect (140). I used an alternative analytic technique as it seemed logical to carry-out the analyses at this level since VMMC services were delivered at community-level.

An allocation scheme was not available. I assumed that service allocation was biased towards urban sites with a larger population and higher HIV-prevalence. I explored whether distance to a hospital was a potential confounder. I plotted distance to a hospital, which I estimated using ArcGIS™, against the estimated cluster-level recent HTC. I found no evidence of an association with recent-testing and therefore did not adjust for distance.

Baseline analyses in CRTs are recommended to describe the study population and explore imbalances in characteristics across arms (140). Where there are imbalances in factors associated with the outcome, these variables act as confounders. I had no baseline data as services had been scaled-up since 2009. I compared the distribution of variables found to be associated with recent HIV-testing in 2011/12 (26) by study sites where VMMC services had and had not been scaled-up and adjusted variables found to be imbalanced across these two groups.

I estimated a crude prevalence difference (PD) by comparing the mean prevalence of recent HIV-testing in sites where VMMC services had been scaled-up to the mean in sites where services had not. I estimated a 95%CI for the PD (140). I adjusted the effect estimate for potential confounders in a stepwise manner:

> Model 1: the crude overall effect of VMMC services on recent HIV-testing
>
> Model 2: Model 1 + *a priori* considered cluster-level confounders + age + district
>
> Model 3: Model 2 + adjustment for imbalances in factors associated with recent HIV-testing

To adjust estimates, I regressed the outcome on the variables using standard logistic regression. I used the *predict* command in Stata 13.0 to estimate the predicted probability of the outcome conditional on the variables in the model. I summarised the data to cluster-level and obtained a residual for each study site by estimating the difference between the observed and predicted outcomes. I summarised the residuals by the two groups, estimated the PD and 95%CI, and conducted a test of significance to determine whether the prevalence differed across the two groups.

I explored how much of the effect was due to recent circumcisions (direct pathway) by adjusting for self-reported recent circumcision (Model D) and whether there was evidence for an indirect effect by adjusting for knowledge of VMMC services availability and of the partial protective effect of circumcision (Model I).

Model D: Model 3 + self-reported recent circumcision

Model I: Model D + knowledge of HIV-prevention benefits and of VMMC service availability

The BHOMA intervention was not expected to confound the relationship between VMMC services and HIV testing. However, where BHOMA had been implemented for longer, clinical staff may be more likely offer PITC, which may modify the effect of VMMC services on recent-testing. To explore evidence for interaction, I included a categorical variable for the BHOMA implementation step and ran an analysis of variance of VMMC, BHOMA and interaction between these two variables. Where there was evidence of interaction ($p<0.05$) I report the stratum specific PD and their 95%CI. It should be noted that my study is unlikely to be powered to detect an interaction effect (140).

4.5 Ethical Approval

I obtained approval to conduct the research presented in this thesis from the Zambian Ministry of Health and the Ministry of Community Development, Mother and Child Health. I obtained ethical approval to add additional questions to the BHOMA individual questionnaire, to conduct secondary analyses on this data and to conduct the systematic observations from the University of Zambia Research Ethics Committee and the London School of Hygiene and Tropical Medicine Ethics Committee. I also received approval to conduct the systematic observations from district health offices. SFH provided me with monitoring data after approval was obtained from the Ministry of Health to conduct this research.

Section 3: Results

Chapter 5. Characteristics of the Study Sites

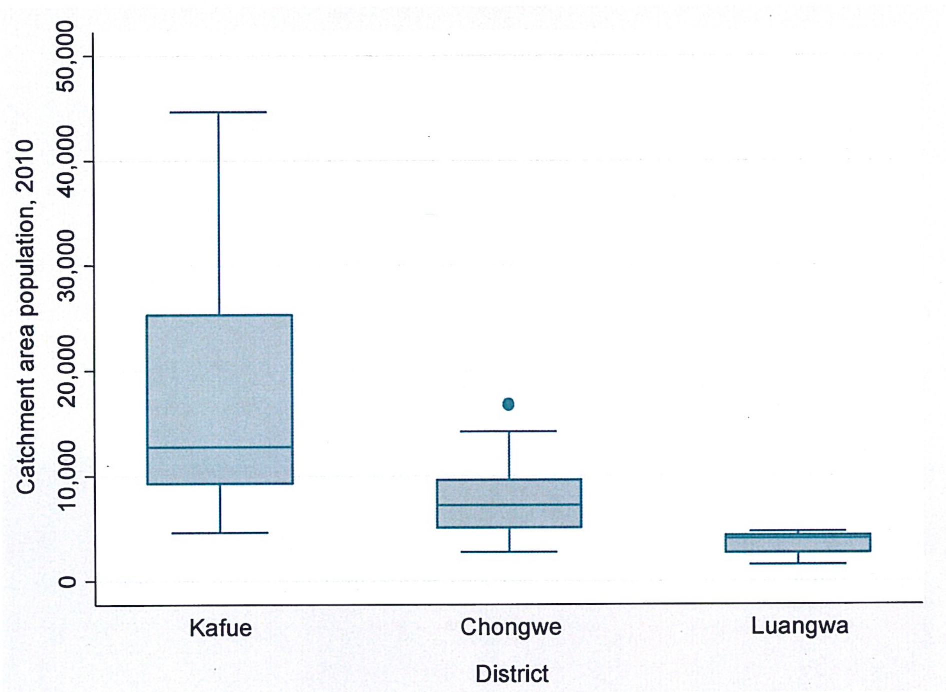
In this chapter, I will describe characteristics of the study sites, including the location and catchment population of the 42 health facilities. I will also describe the availability and promotion of HTC and VMMC services within the study sites.

5.1 Characteristics of the Study Sites

The 42 study sites were located in three contiguous districts of Lusaka Province. Half (n=21, 50%) were in Chongwe district, 33% (n=14) in Kafue and 17% (n=7) in Luangwa. Some 81% (n=34) of sites were rural, 19% (n=8) were peri-urban. The majority of peri-urban sites (75%, n=6) were in Kafue district. In Chongwe, 43% (n=9) of health facilities were <5km from the Great East Road. Six sites (43%) in Kafue were <3km from the T2 highway. The seven facilities in Luangwa were along an 80km road linking the district capital to the Great East Road.

In 2010, the estimated population of each health facility catchment area ranged from 1501 to 44,658. Sites in Luangwa district were the least populated (Figure 13). The estimated population of adult men (15-64 years) ranged from 378 to 11455. In 2011, the median estimated adult male population was 2,141 men (interquartile range (IQR): 1206-3409). By 2013, the median estimated population of men per site was 2,307 (IQR: 1279-3701).

Figure 13. Boxplot of the estimated catchment population of the 42 health facilities, 2010



A level one government-run district hospital was located in Chongwe and Kafue districts. A health facility in Chongwe and Luangwa were church-supported mission hospitals. Excluding the mission hospitals, most health facilities (n=37, 93%) were within 50km of a hospital (median=22km; IQR: 10-30km). Two health facilities in Kafue were more than 75km from the district hospital. A facility in Chongwe was 54km from a mission hospital. In the 2011 audit, all 42 health facilities reported having at least one qualified healthcare worker on staff. Half (n=21/41; 50%) of health facilities had five or fewer members of staff (139). Some 61% (n=19/31) had at least one clinical officer on staff, 7% (n=2/29) a physician. In 2012, half (n=20/40; 50%) the facilities had 1-5 members of staff. More than half (n=24/40; 60%) had at least one clinical officer on staff. Some 3% (n=1) had a physician on staff.

5.2 Availability and Promotion of HTC Services

In the 2011 audit, all facilities offered walk-in VCT services (Table 6). In 2012, two facilities in Luangwa (33%) did not offer walk-in VCT In both audits, walk-in VCT services were available for more than five days a week in most health facilities. In 2011, staff had been trained on the delivery of HTC services in the previous 12 months in half (n=11; 52%) of facilities in Chongwe, 39% (n=5) in Kafue and 29% (n=2) in Luangwa. All facilities had HIV-test kits available. In 2012, staff had been trained on HTC service delivery in half the facilities in Chongwe (n=9; 47%) and Luangwa (n=6; 50%), and in 36% (n=5) of facilities in Kafue. HIV-testing kits were not observed at a facility in Luangwa (n=1; 17%). In 2011, 26% (n=11) of facilities in the three districts had unexpired ART on-site. In 2012, 57% (n=8) of facilities in Kafue, 50% (n=10) in Chongwe and 33% (n=2) in Luangwa had unexpired ART.

Posters were the only type of HTC- and VMMC-related promotion observed in 35 (83%) of the study sites (Figure 14). Half (n=137/272; 50%) of all observed posters were HTC- or VMMC-related. Most were observed at the health facility (n=125; 91%), 10% (n=12) within the 1.5km radius of the facility.

HTC-related posters were observed in 79% (n=11) of sites in Kafue, 81% (n=17) in Chongwe and 71% (n=5) in Luangwa. Some 86% (n=108/125) of posters at the health facilities included HTC-related messaging, 41% (n=44) of which promoted couples HTC, 14% (n=15) mentioned couples HTC as an HIV-prevention measure and 4% (n=4) targeted men (Figure 9; posters 1-3). Over half the facilities (n=24; 57%) had at least one poster mentioning couples HTC (n=13; 62% in Chongwe; n=4; 57% in Luangwa; n=7; 50% in Kafue). Posters promoting only couples-HTC were observed in 62% (n=13) of facilities in Chongwe, 21% (n=3) in Kafue and 14% (n=1) in Luangwa (Figure 9Posters 2). Within the 1.5km radius, six HTC-related posters were observed in six (14%) sites. Two posters targeted couples and one men.

Table 6. The capacity of the health facilities to deliver HIV-testing services and availability of HIV-testing kits and ART, 2011 & 2012 audit

		2011 Audit, (n, col %)			2012 Audit (n, col %)		
		Kafue	Chongwe	Luangwa	Kafue	Chongwe	Luangwa
Whether the facility offered VCT services (client walk-in)[1]	No	0	0	0	0	0	2 (33.3)
	Yes	14 (100.0)	21 (100.0)	7 (100.0)	14 (100.0)	19 (100.0)	4 (66.7)
Number of days VCT services are available[2]	1-4	0	1 (5.3)	0	1 (7.1)	4 (25.0)	1 (25.0)
	5+	14 (100.0)	18 (94.7)	7 (100.0)	13 (92.9)	15 (75.0)	3 (75.0)
VCT service guidelines, wall charts or aids available[3]	Observed	10 (71.4)	17 (81.0)	4 (66.7)	12 (85.7)	16 (84.2)	6 (100.0)
	Reported, not observed	1 (7.1)	1 (4.8)	2 (33.3)	1 (7.1)	1 (5.3)	-
	Not Available	3 (21.4)	3 (14.3)	0	1 (7.1)	2 (10.5)	-
VCT register	Observed	14 (100.0)	20 (95.2)	5 (71.4)	14 (100.0)	18 (95.0)	5 (83.3)
	Register not available	0	1 (4.5)	2 (28.6)	0	1 (5.0)	1 (16.7)
When was the VCT Register Last Updated[4]	Within last 7 days	12 (85.7)	18 (85.7)	6 (85.7)	13 (92.9)	17 (89.5)	5 (83.3)
	More than 7 days ago	2 (14.3)	3 (14.3)	1 (14.3)	1 (7.1)	2 (10.5)	-
	Register not available						1 (16.7)
Whether any staff were trained on HTC in last 12 months[5]	No	8 (61.5)	10 (47.6)	5 (71.4)	9 (64.3)	10 (52.6)	3 (50.0)
	Yes	5 (38.5)	11 (52.4)	2 (28.6)	5 (35.7)	9 (47.4)	3 (50.0)
HIV-test kits available –could facility provide HTC on the day of the audit[6]	No	0	0	0	0	0	1 (16.7)
	Yes	14 (100.0)	21 (100.0)	7 (100.0)	12 (85.7)	19 (100.0)	5 (83.3)
ART available[7]	Present, ≥1 unexpired unit	3 (21.4)	6 (28.6)	2 (28.6)	8 (57.1)	10 (50.0)	2 (33.3)
	No valid unit present	11 (78.6)	15 (71.4)	5 (71.4)	6 (42.9)	10 (50.0)	4 (66.7)

Key: VCT – voluntary counselling and testing; HTC – HIV testing and counselling, ART – antiretroviral therapy; Number of facilities missing data in 2011 (RD1) and 2012 (RD2): [1] RD2 – 3; [2] RD1– 2; [3] RD1– 1; [4] RD2 – 1; [5] RD1– 1; [6] RD2 – 2; 2 sites in Luangwa that reported not offering walk-in VCT had test kits available; [7] RD2 - 2

5.3 Availability and Promotion of VMMC Services

In 2013, VMMC services were available at the health facility and/or through outreach in 76% (n=32) of study sites (Table 7). Services were available at 40% (n=17/32) of health facilities. SFH was listed as a service provider in 65% (n=11) of facilities. In 53% (n=9), the health facility/district health teams were listed as service providers. In five (29%) facilities services were first offered in 2013. The frequency of service availability varied from 5 days/week (n=1; 6%) to one day/week in six facilities (35%); one day/month in two facilities (12%) to two days/year in one facility (6%). In other sites, services were available "mostly Saturdays" (n=2; 12%), "on demand" (n=1; 6%) or when there were ≥10 clients (n=1; 6%). Services were available through outreach in the catchment area in half the sites (n=21; 50%). In most of these sites (n=15/21; 71%), services were not offered at the health facility. Five (33%) of the sites were in Luangwa district. SFH was listed as the service provider in 60% (n=9) of sites.

By December 2013, SFH delivered VMMC services in 57% (n=25) of study sites. Services were first delivered in March 2009 in three sites in Chongwe. The number of sites where services were delivered increased from three (7%) in 2009, to 11 (26%) in 2010 and 17 (40%) in 2013. By 2013, VMMC services had been delivered in 71% (n=10) of sites in Kafue, over half in Chongwe (n=11; 52%) and Luangwa (n=4; 57%). Services were delivered in 75% (n=6/8) of urban sites. SFH reported delivering 5307 services, of which 50% (n=2667) were delivered to males aged 15 years or older. Some 5% (n=141) of services were delivered in 2009 and 41% (n=1091) in 2013.

Half (50%, n=21/42) the study sites had at least one VMMC-related poster (Figure 14 & Table 7). Some 26% (n=32/125) of health facility-based posters included VMMC-related messaging. Some 14% (n=17/125) specifically promoted VMMC, 12% (n=15) informed patients that male circumcision, among other measures, can prevent HIV-infection (Figure 9; Poster 3). Some 71% (n=15/21) of sites had one poster. Posters were observed in 71% (n=5) of sites in Luangwa, 57% (n=8) in Kafue and 38% (n=8) in Chongwe. Six VMMC-related posters were identified in the 1.5km radius in four (11%) sites. In three, posters informing residents that VMMC services would be available at the health facility were observed. In one site a poster informing residents that services were available at a ZNS clinic was observed.

Table 7. The availability, delivery and promotion of VMMC services in the study sites, by district

		Kafue	Chongwe	Luangwa
Adult VMMC services offered at the facility	No	9(64.3)	11 (52.4)	5 (71.4)
	Yes	5 (35.7)	10 (47.6)	2 (28.6)
Organisation that offered VMMC services at the facility[1]	Health facility/district health office	2 (40.0)	5 (50.0)	2 (100)
	SFH	4 (80.0)	7 (70.0)	0
	MSI	0	2 (20.0)	0
	CIDRZ	2 (40.0)	3 (30.0)	0
Year services first offered at the health facility[2]	2005-2008	-	1 (10.0)	1 (50.0)
	2009-2010	1 (25.0)	1 (10.0)	-
	2011-2012	3 (75.0)	4 (40.0)	-
	2013	-	4 (40.0)	1 (50.0)
Adult VMMC services offered through outreach services	No	7 (50.0)	14 (66.7)	0
	Yes	7 (50.0)	7 (33.3)	7 (100)
Organisation that offered VMMC services through outreach[3]	Health facility/ district health office	5 (71.4)	3 (42.9)	5 (71.4)
	SFH	5 (71.4)	1 (14.3)	3 (42.9)
	MSI	2 (28.6)	1 (14.3)	0
Year services first offered through outreach[4]	2005-2008	-	-	-
	2009-2010	1 (16.7)	2 (40.0)	2 (40.0)
	2011-2012	3 (50.0)	-	-
	2013	2 (33.3)	3 (60.0)	3 (60.0)
Adult VMMC services offered at the facility and/or through outreach	No	4 (28.6)	6 (28.6)	0
	Yes	10 (71.4)	15 (71.4)	7 (100)
SFH delivered any VMMC services between 2009 and 2013	No	4 (28.6)	10 (47.6)	3 (42.9)
	Yes	10 (71.4)	11 (52.4)	4 (57.1)
VMMC-related posters observed in study sites, 2013	No	6 (42.9)	13 (61.9)	2 (28.6)
	Yes	8 (57.1)	8 (38.1)	5 (71.4)

Footnotes: SFH – Society for Family Health; MSI – Marie Stopes International; CIDRZ – Center for Infectious Disease Research Zambia; [1] Data on the service provider equal to more than N as more than one provider could be mentioned, data missing for n=2 in Chongwe; [2] Data missing for n=1 in Kafue, [3] Data on service provider does not equal N as more than one provider could be listed, data missing for n=3 in Chongwe and n=1 in Luangwa; [4] Data missing for n=2 in Chongwe & Luangwa, n=1 Kafue;

Figure 14. Flow diagram of the number and type of posters observed in the study sites, 2013

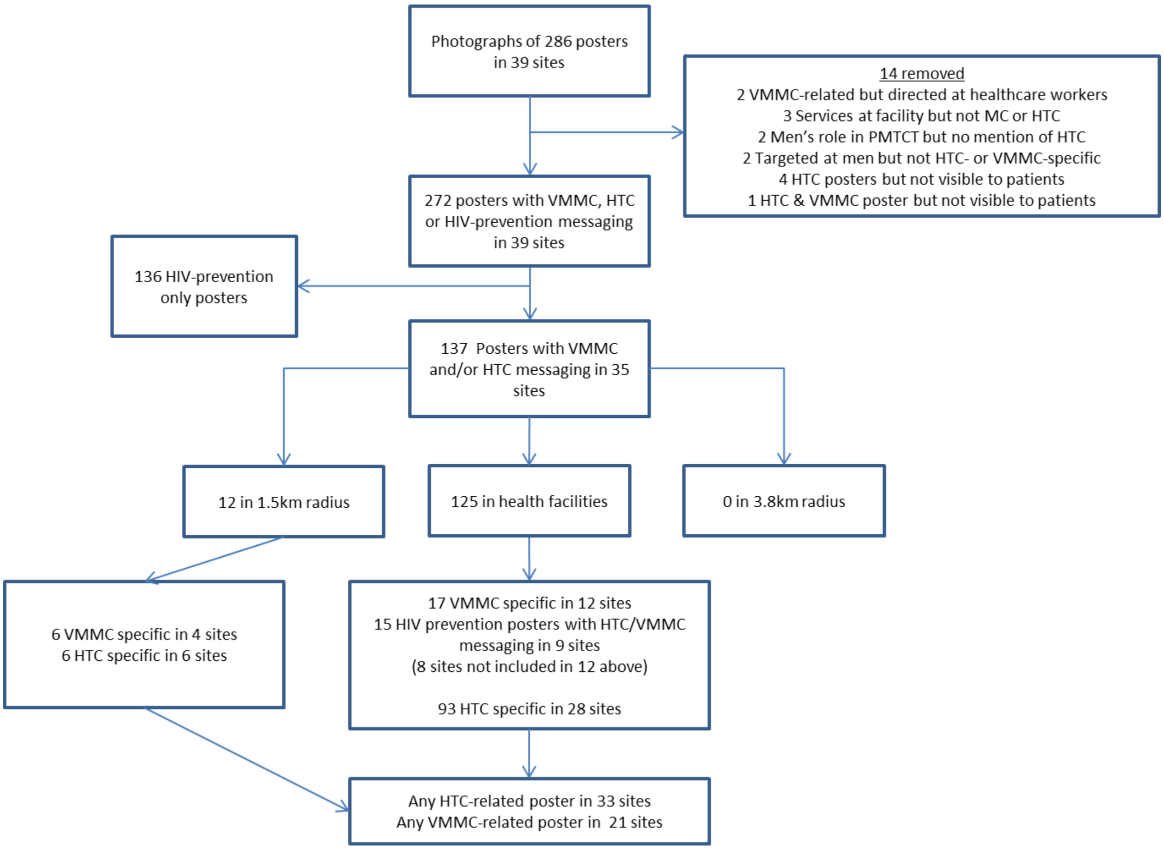
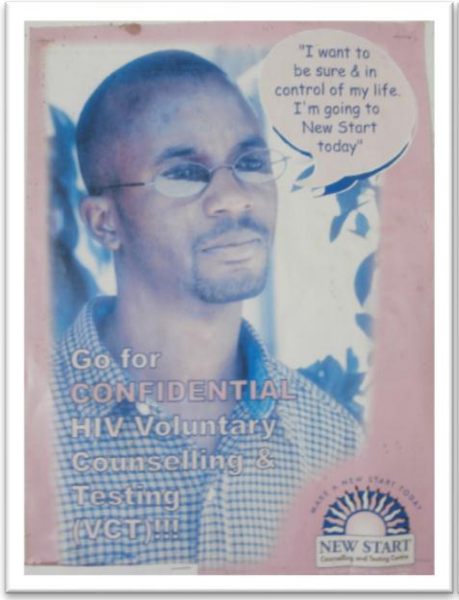
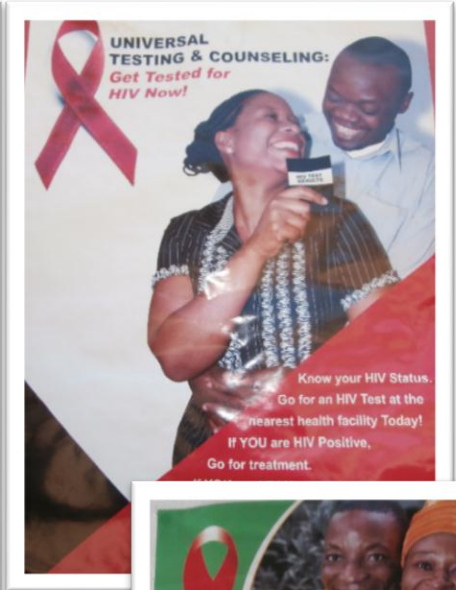


Figure 15. Examples of HTC-related posters targeted at men (1) and couples (2) and mentioning HTC (3), and VMMC-related posters (3 & 4) observed in the study sites during systematic observations, 2013

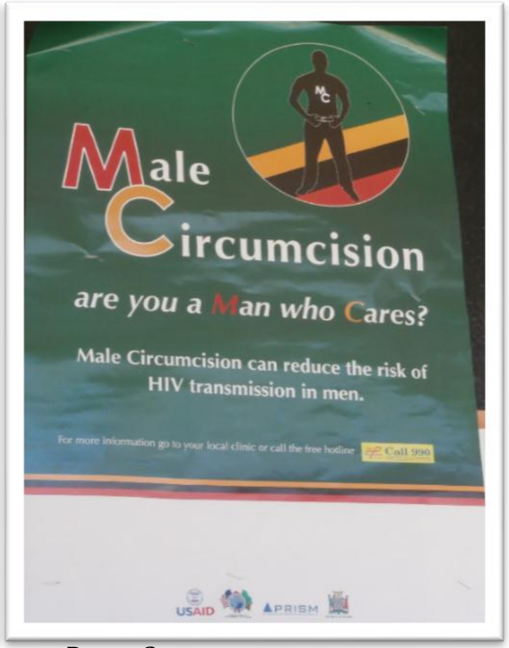


Poster 4



Poster 1.

Poster 3



Poster 2

5.4 Chapter Summary

Most of the study sites were rural, with varying health facility catchment populations. Most facilities had HIV-testing kits on-site and reported offering walk-in VCT. Less than half of the facilities reported staff training on the delivery of HTC services in the previous 12 months and few had non-expired ART available, particularly in 2011. In 2013, posters promoting HTC were observed at the health facility in the majority of study sites. Few posters targeted men specifically. Over half the sites had at least one poster mentioning couples HTC. In over half the sites in Chongwe, posters specifically promoting couples HTC were observed.

By 2013, VMMC services were available at the health facility and/or through outreach in most study sites. SFH and district health staff were cited as the primary VMMC service providers. Over 60% of sites reported that services were first offered in 2012 or later. The frequency of service availability varied from 5 days/week, 2 days/year to “on demand”. SFH had delivered VMMC services to males of all ages in more than half the sites. The systematic observations identified little evidence for widespread VMMC service promotion, posters were the only form of promotion observed. VMMC-related posters were observed in over half the sites in Kafue and Luangwa. Few sites had posters within the 1.5km radius and no posters were observed in high density areas within the 3.8km radius.

Chapter 6: Characteristics of the households and participants in the population-based survey

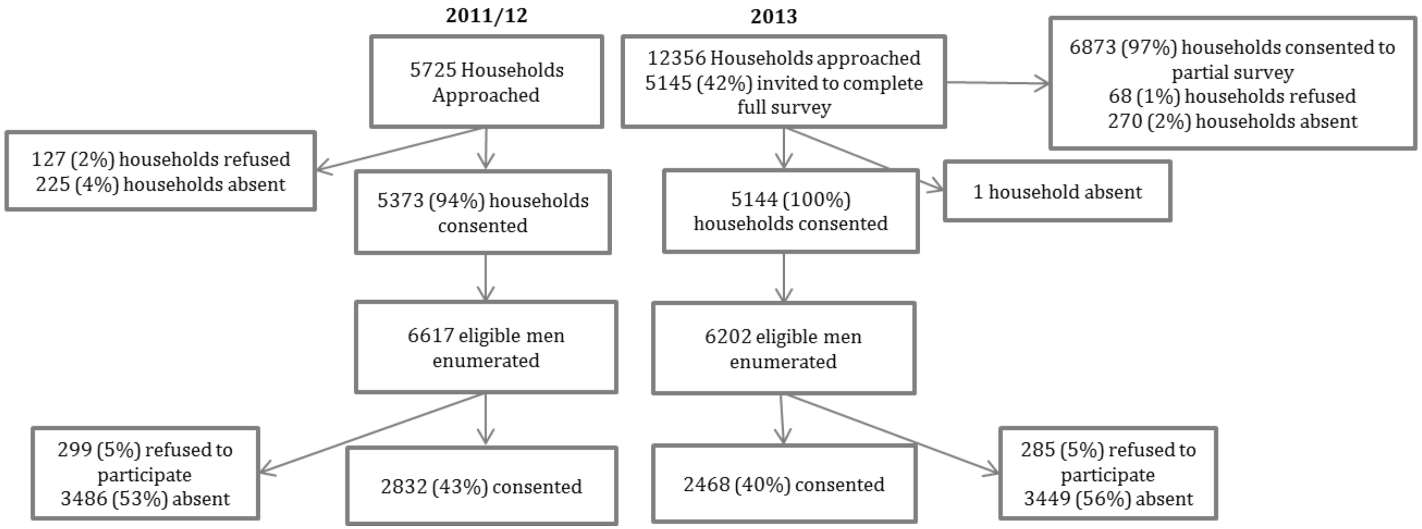
In this chapter I will describe participation in the household and individuals surveys and compare participating males to men to non-participants. I will describe the characteristics of the males participating in the two surveys, including their age, levels of education and levels of ever- and recent-testing for HIV. I compare ever- and recent-testing outcomes to women's and by age. I describe men's knowledge of HTC service availability and of measures to prevent HIV, and describe the year in which men reported their first HIV-test.

6.1 Participation in the Household survey

Of the 5725 households invited to participate in the 2011/12 survey, 94% (n=5373) consented, 2% (n=127) refused and 4% (n=225) were absent. In consenting households, enumeration identified 6617 eligible men (Figure 16; (26)).

The 2013 survey was conducted approximately 18 months after the 2011/12 survey in each study site. Of the 12356 households invited to participate in the survey, 97% (n=12017) consented, 2% (n=270) were absent and 1% (n=68) refused. Of the households, 43% (n=5145) were invited to participate in a full survey. Almost all households consented (n=5144, 100%) with one household absent. Enumeration identified 6202 eligible men in consenting households (Figure 16).

Figure 16. Flow Diagram of household and individual participation in the 2011/12 and 2013 population-based surveys



6.2 Participation in the Individual Survey

Of the 6617 men enumerated in the 2011/12 survey, 43% (n=2832) consented to participate in the individual survey (Figure 13; (26)). Some 4% (n=240) of men absent at the time of the household visit were absent in the month preceding the survey. Overall, 95% (n=6295) of enumerated men had no missing data and were present in the month preceding the survey.

In 2013, 56% (n=3449) of men were absent at the time of the household visit and few refused to participate (n=285, 5%). Non-participation varied across sites (median 60%, range 41%-78%). Some 6% (n=374) of men absent at the time of the household visit were absent in the month preceding the survey. Overall, 93% (n=5797) of enumerated men had no missing data and were present in the month preceding the survey. The number of participants per site ranged from 31 to 93 (median: 61; IQR: 51-74). Participation in the 2011/12 and the 2013 surveys were strongly correlated (r=0.30; p<0.01). Participation in both rounds was negatively correlated with population (2011/12: r=-0.40 & 2013: r=-0.40; p<0.01).

The factors associated with survey participation were similar in both surveys (14). Findings for the 2013 survey are presented in Research Paper III (14). In 2011/12, men aged >25 years were more likely to participate than men aged 15-24 years; those who were present in the household fulltime in the previous six months were less likely to participate relative to men with a period of being absent (Table 8). Household heads were more likely to participate than men not listed as a head (n=1706; 50% compared to n=1100; 38%; PR=1.35 95%CI 1.27-1.43). Men of lowest SEP (n=471; 49%) were more likely to participate than men of highest SEP (n=605; 39%; PR=0.86 95%CI: 0.77-0.95).

Table 8. Distribution of Characteristics of Participants and Factors Associated with Survey Participation in the 2011/12 survey

		Distribution (n, col %)	Participant (n, row %)	Crude PR (95%CI)
		6295	2806 (44.6)	-
Age category	15-24	2473 (39.3)	1062 (42.9)	1.0
	25-59	3822 (60.7)	1744 (45.6)	1.08 (1.01-1.14)
Head of Household[1]	No	2903 (46.1)	1100 (37.9)	1.0
	Yes	3392 (53.9)	1706 (50.3)	1.35 (1.27-1.43)
Present consecutively in previous 6mth	No	486 (7.7)	283 (58.2)	1.0
	Yes	5809 (92.3)	2523 (43.4)	0.72 (0.67-0.78)
Household-level				
SEP	Lowest	962 (15.3)	471 (49.0)	1.0
	Low	1180 (18.8)	572 (48.5)	0.99 (0.90-1.08)
	Middle	1251 (19.9)	574 (45.9)	0.98 (0.89-1.07)
	High	1336 (21.2)	584 (43.7)	0.95 (0.85-1.04)
	Highest	1566 (24.9)	605 (38.6)	0.86 (0.77-0.95)
Household Size	1-5	2931 (46.6)	1522 (51.9)	1.0
	6-10	2955 (46.9)	1157 (39.2)	0.73 (0.69-0.78)
	>10	409 (6.5)	127 (31.1)	0.59 (0.50-0.68)
Cluster- & District-level				
Urban site	No	5118 (81.3)	2391 (46.7)	1.0
	Yes	1177 (18.7)	415 (35.3)	0.75 (0.63-0.86)
District	Kafue	2181 (34.7)	841 (38.5)	1.0
	Chongwe	3195 (50.8)	1469 (46.0)	1.20 (1.07-1.33)
	Luangwa	919 (14.6)	496 (53.7)	1.40 (1.21-1.59)

Key: Mth- month; [1]Some 8% (n=404) of households had no or more than one household head listed. In these households, I assumed the eldest male was the household head.

6.3 Characteristics of Consenting Households

In 2011/12, the number of consenting households per site ranged from 119 to 142 (median: 127; IQR: 123-132). The number of household members per household ranged from 1 to 20 (median: 5; IQR: 3-7). For almost all households (n=5009, 93%), the preferred health facility for ill family members was the health facility of the catchment area. Among households with data on time to travel to the facility, over half (n=2550, 51%) took more than 30 minutes to travel to the preferred health facility.

In 2013, the number of consenting households ranged from 163 to 332 (median: 302; IQR: 262-305). The number of household members per household ranged from 1 to 25 (median: 6; IQR: 5-8). Some 99% (n=5794) reported the local health facility as their preferred facility. Among households with data on time to travel to the facility, 31% (n=3202) reported that it took 30-60 minutes to travel to the health facility, with 17% (n=1788) reporting 1-2 hours.

6.4 Characteristics of Participants

In the 2011/12 survey, the median age was 29 years (IQR: 20-39; Table 9). Few men (n=98, 4%) reported no education. Some 57% (n=1619) had completed a level of secondary education or higher. Some 35% (n=985) of men were Protestant and 28% (n=784) Catholic. Over half the men were married (n=1487; 53%). Some 30% of consenting men were linked to a spouse, among whom 15% (n=130) had a pregnant spouse. The majority of spouses (n=736, 83%) reported ever-testing for HIV. Approximately 21% (n=605) of men resided in a household of highest SEP.

The characteristics of men participating in the 2013 survey were similar to characteristics of men participating in the 2011/12 survey (Table 9). Median age was 29 years (IQR: 21-39) and over half (n=1324, 54%) were married. More than half (n=1408; 57%) completed some secondary education or higher. Of married men linked to a spouse (n=752; 57%), 90% (n=674) had a spouse who reported a history of HIV-testing.

Roughly 19% (n=476) of men resided in a household of highest SEP, 22% (n=536) in a household of middle SEP. More than half resided in a site where more than 50% of men were employed (n=1460; 59%). Almost half (n=1121, 45%) resided in a cluster where the health facility had ART available on the day of the audit.

Table 9. Distribution of Characteristics of Men Consenting to Participate in the 2011/12 and the 2013 Survey

		Distribution (n, col %)	
		2011/12 (N=2832)	2013 (N=2468)
History of HIV testing[1]	No	1348 (47.6)	902 (36.6)
	Yes	1480 (52.3)	1538 (62.3)
Age[2]	15-19	607 (21.5)	501 (20.3)
	20-29	831 (29.4)	777 (31.5)
	30-39	683 (24.2)	568 (23.0)
	≥40	705 (25.0)	610 (24.7)
Household Head	No	1116 (39.4)	926 (37.5)
	Yes	1716 (60.6)	1542 (62.5)
Education[3]	No education	98 (3.5)	68 (2.8)
	Primary	1113 (39.3)	989 (40.1)
	Secondary or higher	1619 (57.2)	1408 (57.1)
Occupation (2013 survey only) [4]	None	-	1127 (46.4)
	Agriculture (other's land)		544 (22.4)
	Agriculture (own land)		462 (19.0)
	Professional/services		297 (12.2)
Religion[5]	Protestant	985 (34.8)	919 (37.3)
	Catholic	784 (27.7)	627 (25.4)
	SDA	339 (12.0)	371 (15.0)
	Other	605 (21.4)	441 (17.9)
	None	93 (3.3)	101 (4.1)
Marital Status[6]	Single	1201 (42.4)	1035 (42.0)
	Married/cohabiting	1487 (52.5)	1324 (53.7)
	Separated/divorced	111 (3.9)	84 (3.4)
	Widowed	33 (1.2)	24 (1.0)
Present six months	No	290 (10.2)	116 (4.7)
	Yes	2542 (89.8)	2352 (95.3)
HIV Status[7]	Negative	1300 (91.4)	1340 (92.9)
	Positive	110 (7.7)	101 (7.0)
History of TB Treatment[8]	No	2740 (96.8)	2377 (96.4)
	Yes	91 (3.2)	89 (3.6)
Spouse Characteristics (2011/12 survey N=885; 2013 survey N=752)			
Currently Pregnant[9]	No	749 (84.3)	651 (86.6)
	Yes	130 (14.6)	100 (13.3)
Wife Reports having ≥1 Child	No	56 (6.3)	38 (5.1)
	Yes	829 (93.7)	714 (94.9)
Wife Previously HIV-tested[10]	No	149 (16.8)	77 (10.2)
	Yes	736 (83.1)	674 (89.7)

Household-level Characteristic			
SEP Group[11]	Lowest	471 (16.6)	463 (18.8)
	Low	572 (20.2)	471 (19.1)
	Middle	574 (20.3)	536 (21.7)
	High	584 (20.6)	516 (20.9)
	Highest	605 (21.4)	476 (19.3)
Size of Household	1-5	1529 (54.0)	1326 (53.7)
	6-10	1172 (41.4)	1030 (41.7)
	>10	131 (4.6)	112 (4.5)
Cluster-level Characteristics			
Urban cluster	No	2407 (85.0)	2047 (82.9)
	Yes	425 (15.0)	421 (17.1)
HIV Prevalence	<10%	2242 (79.2)	1955 (79.2)
	>10%	590 (20.8)	512 (20.8)
>50% of Men Employed	No	-	1008 (40.8)
	Yes		1460 (59.2)
>25% Know 3+ Measures to Prevent HIV-infection	No	-	1174 (47.6)
	Yes		1294 (52.4)
ART at Local Health Facility[12]	No	2110 (74.5)	1217 (49.3)
	Yes	722 (25.5)	1121 (45.4)
District	Kafue	864 (30.5)	863 (30.5)
	Chongwe	1472 (52.0)	1474 (52.1)
	Luangwa	496 (17.5)	495 (17.5)

Key: Missing data 2011/12 survey (RD1) & 2013 survey (RD2): 1 RD1– 4 & RD2 – 27; 2 RD1– 6 & RD2 – 12; 3 RD1- 2 & RD2 – 3; 4 RD2 – 38; 5 RD1– 26 & RD2 – 9; 6 RD2 – 1; 7 RD1– 1422 & RD2 – 1027; 8 RD1& RD2 – 1; 8 RD1 – 1 & RD2 – 2; 9RD1– 9 & RD2 – 1; 10 RD1& RD2 – 1; 11 RD1– 26 & RD2 – 6; 12 RD2 – 130

6.5 Levels of HIV-testing by Sex and Age

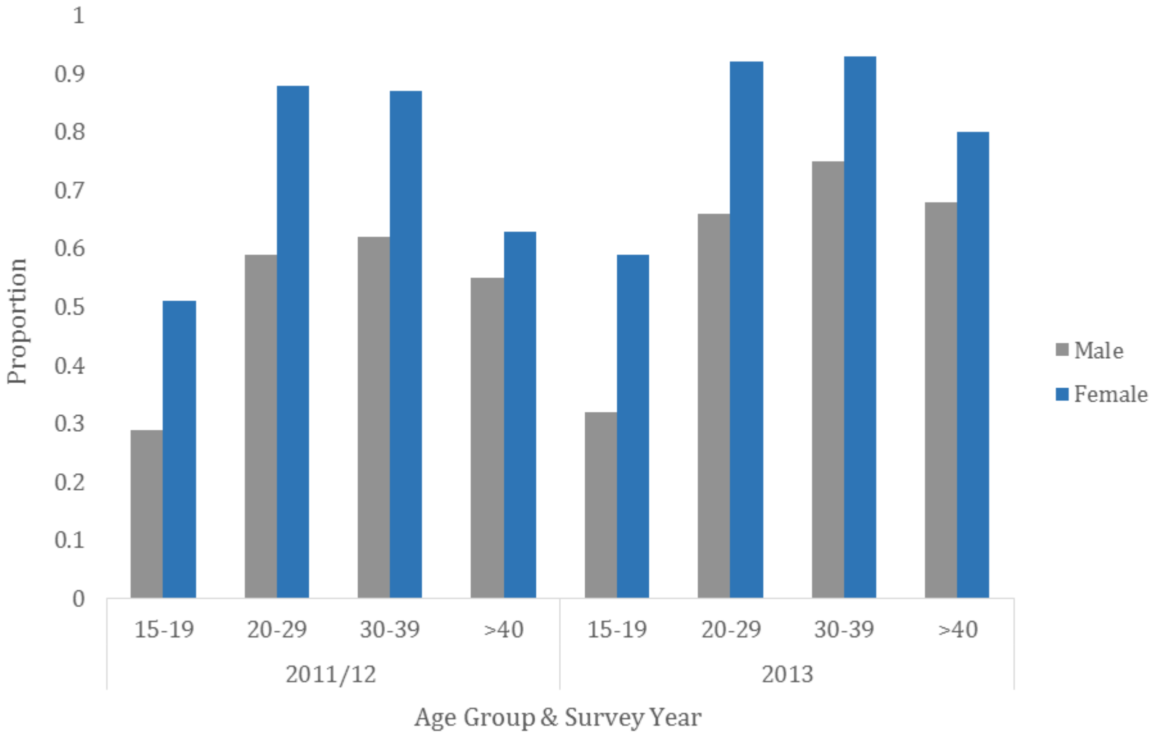
In 2011/12, 67% (n=4940) of individuals reported ever-testing for HIV. Ever-testing was higher among females than males (76% vs 52%, respectively; p<0.01). Patterns were similar for recent-testing (n=1760; 39% versus n=709; 25%, respectively). Excluding HIV-positive individuals who reported their last HIV-test more than one year prior to the survey, 40% of women compared to 26% of men tested recently. Across study sites, women's recent-testing ranged from 23% to 58% (median=40%; IQR: 34%-48%).

In 2013, ever-testing among females increased to 84% (n=3308). For males, ever-testing increased by 21%, with 61% (n=1459) ever-testing and receiving the result of an HIV-test. Some 44% (n=1715) of females recently-tested compared to 31% (n=716) of males. Removing individuals diagnosed HIV-positive more than one year prior to the survey, 46% of females and 30% of males recently-tested. Across study sites, recent-testing ranged from 26% to 65% (median=43%; IQR: 35%-51%) and from 13% to 52% (median=31%; IQR: 23%-38%), respectively.

By age group, in 2011/12, 51% (n=434) of females aged 15-19 years ever-tested compared to 29% (n=173) of males. In 2013, levels were 59% and 34%, respectively. Some 32% (n=159) of males ever-tested and received the result of an HIV-test (Figure 17). In 2011/12, 87% of females and 62% of males aged 30-39 ever-tested. By 2013, levels were 93% (n=612) and 75% (n=408), respectively.

In 2011/12, some 30% (n=252) of females aged 15-19 years recently-tested compared with 15% (n=89) of males. In 2013, levels were 33% (n=235) and 17% (n=86), respectively. In 2011/12, 45% (n=461) of women and 32% (n=213) of men aged 30-39 years recently-tested. This compared with 52% (n=445) of women and 37% (n=192) of men in 2013.

Figure 17. Bar chart of levels of self-reported ever-testing for HIV by sex and age group, 2011/12 and 2013



Footnote 1. For men results are ever-tested and received the result of an HIV-test

6.6 Knowledge of HTC service availability and reasons for HIV-testing

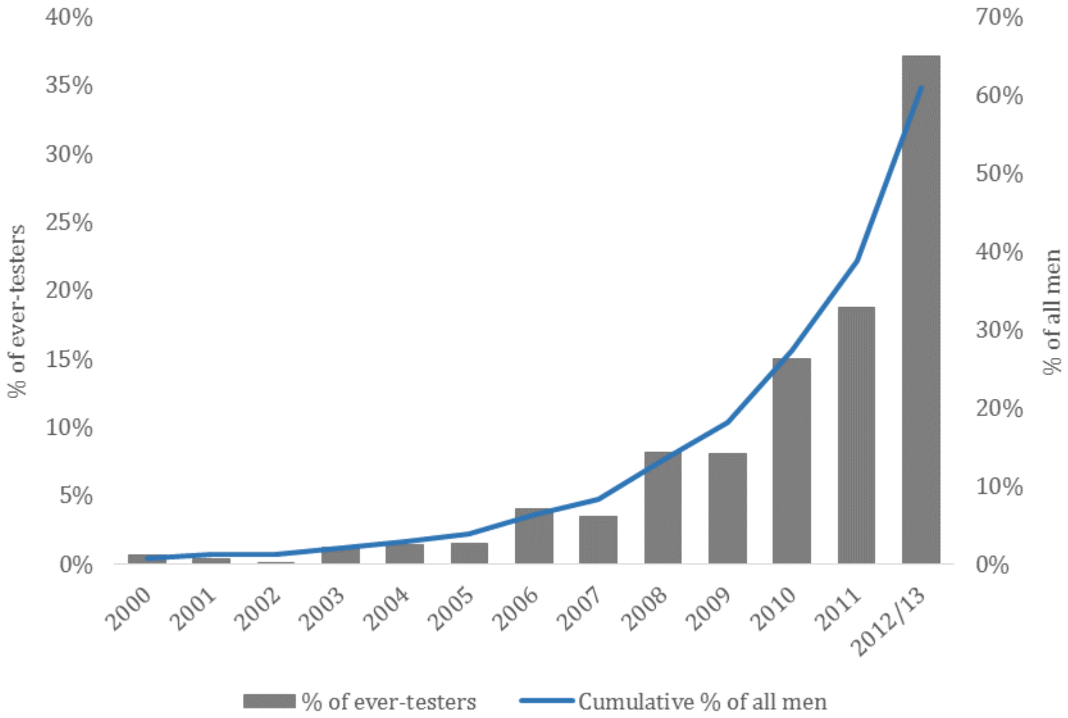
In 2013, 77% (n=1833) of men stated that HTC services were available in their community among whom 90% (n=1652) reported that services were available at the local health facility. Some 8% (n=138) reported that services were also available through VMMC clinics and 10% (n=176) through mobile clinics.

Some 36% (n=527) of ever-testers cited "other" as the reason for their most recent HIV-test, 22% (n=314) cited feeling sick and worried. Some 17% (n=253) reported that HIV-testing was recommended by a healthcare worker, 10% (n=145) that their partner/spouse was pregnant or requested them to go for HIV-testing and 8% (n=122) reported retesting after having a test during the "window period". Among never-testers, the most commonly cited reason for never-testing was not thinking one was HIV-positive (n=357; 41%), followed by "other" reasons (n=298; 33%) and being afraid to know ones HIV-status (n=195; 22%).

6.7 Trends in the year of incident HIV-test

Less than 1% (n=14/1459) of ever-testers reported their first HIV-test before 2000. Of those testing post-2000, 13% (n=184/1445) first-tested for HIV between 2000 and 2007. Incident HIV-testing increased post-2007. Some 8% (n=115) of ever-testers reported their first HIV-test in 2009, 15% (n=215) in 2010 and 21% (n=312) in 2012 (Figure 18). Among all men, some 20% had a first HIV-test by 2009, increasing to 27% in 2010 and to roughly 50% by 2012.

Figure 18. Bar chart of the year in which ever-testers reported their first HIV-test and line graph of the cumulative proportion of all men ever-tested by year, 2000-2013



6.8 Chapter Summary

More than half of the men eligible for participation in the individual surveys were absent at the time of the household visit. Household heads, men residing in Luangwa and men of lowest SEP were more likely to participate. The median age of participating men was 29 years and over half were married and had completed some secondary education. More than half were listed as a head of their household and, in 2013, almost half reported no employment.

Over half the men reported ever-testing for HIV in both surveys. Ever-testing increased significantly across the two surveys. Women's levels of ever HIV-testing remained roughly 40% higher than men's in both surveys. By 2013, almost one-third of all men reported a recent HIV-test. Women's levels of recent-testing were 50% higher. There was variation in levels of ever- and recent-testing across the study sites and by age groups. The majority of men were aware that HTC services were available, few reported that services were available through mobile or VMMC clinics. More than one-third of ever-testers cited "other" as the reason for their most recent HIV-test and not thinking one was HIV-positive was the most commonly cited reason for never-testing. By 2009, 20% of all men had had a first HIV-test increasing to 40% in 2011.

Chapter 7. Factors Associated with Men's HIV-Testing Behaviours

7.1 Preamble to Paper II: Factors associated with HIV-testing and acceptance of an offer of home-based testing by men in rural Zambia

Effective strategies to increase men's levels of HIV-testing are available (19). Whether the expansion of these alternate strategies has contributed to increasing men's population-levels of HIV-testing warrants investigation. Research Paper II describes men's levels of HIV-testing in the study area in 2011/12. At the time of the survey, HTC services were primarily facility-based. Progress had been made in implementing PITC and couples HTC through ANC settings. Mobile HTC services were also being made available (138, 139). The paper also explores the factors associated with ever-testing and recently-testing for HIV.

Home-based HIV-testing is an example of a community-based HTC strategy. Similar to other community-based strategies, offering home-based HIV-testing is expected to increase equity in access to services. Research Paper II describes the level of acceptance of the offer of home-based HIV-testing, offered in the context of research rather a home-based HIV-testing programme, and explores the factors associated with acceptance among all men, regardless of HIV-testing history, and whether the offer of home-based HIV-testing, meets these expectations.

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SECTION A – Student Details

Student	.Bernadette Hensen
Principal Supervisor	James Hargreaves
Thesis Title	Increasing men's uptake of HIV-testing in sub-Saharan Africa: a systematic review of interventions and analyses of population-based data from rural Zambia

If the Research Paper has previously been published please complete Section B, if not please move to Section C

SECTION B – Paper already published

Where was the work published?	AIDS and Behavior		
When was the work published?	August 2014		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion			
Have you retained the copyright for the work?*	**No**	Was the work subject to academic peer review?	**Yes**

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SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	
Please list the paper's authors in the intended authorship order:	
Stage of publication	**Submitted**

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I conceived the idea for the manuscript with James Hargreaves. I planned, with support from James Hargreaves and James Lewis, and conducted all analyses. I interpreted the findings and wrote the first draft of the manuscript. I responded to authors suggestions on the draft manuscript and to

	reviewers comments as appropriate.

Student Signature: [signature] **Date:** 15/7/15

Supervisor Signature: [signature] **Date:** 14/7/15

7.2 Research Paper II

Factors Associated with HIV-Testing and Acceptance of an Offer of Home-Based Testing by Men in Rural Zambia

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Abstract: The objective of this study is to describe HIV-testing among men in rural Lusaka Province, Zambia, using a population-based survey for a cluster-randomized trial. Households (N=120) were randomly selected from each of the 42 clusters, defined as a health facility catchment area. Individuals aged 15–60 years were invited to complete questionnaires regarding demographics and HIV-testing history. Men testing in the last year were defined as recent-testers. After questionnaire completion adults were offered home-based rapid HIV-testing. Of the 2,828 men, 52% reported ever-testing and 25% recently-testing. Factors independently associated with ever- and recent-testing included age 20+ years, secondary/higher education, being married or widowed, a history of TB-treatment and higher socioeconomic position. 53% of never-testers and 57 % of men who did not report a recent-test accepted home-based HIV-testing. Current HIV-testing approaches are inadequate in this high prevalence setting. Alternative strategies, including self-testing, mobile- or workplace-testing, may be required to complement facility-based services.

Introduction

Demographic and Health Surveys (DHS) in sub-Saharan Africa highlight persistent and growing sex disparities in self-reported HIV-testing [1–3]. This disparity is in part attributable to the successful implementation of provider-initiated testing (PITC) in antenatal care (ANC) settings [4]. With lower knowledge of HIV-status, fewer HIV-positive men in sub-Saharan Africa initiate ART compared with women, access ART at later stages of immune-suppression and are more likely to die once ART-initiated [5].

Mobile- and home-based delivery of HIV-testing services may encourage more men to test [6–10]. The World Health Organization (WHO) recommends the implementation of a combination of facility- and community-based models of HIV testing and counseling (HTC) in generalized epidemics to reach all populations including men [8]. However, relatively little is known about trends and factors associated with men's HIV testing, with much of the available evidence arising from urban settings [11–13] or conducted prior to or in 2007, when WHO recommended that PITC be offered in all health facility settings in generalized epidemics [14, 15].

To our knowledge, there are only a few population-based surveys that explore factors associated with Zambian men's HIV-testing [16–18]. Of these studies, one explores factors associated with ever-testing among married men using the 2001–2 Zambian DHS [18]. The second is a nationally representative survey conducted in 2007 to explore factors associated with testing in the 12 months preceding the survey [17]. The third study, conducted from September 2010 through January 2011, explores the associations between social relations and tolerance to gender-based violence, and not testing for HIV among a relatively small sample of men (N=708) [16]. To increase the evidence base of factors associated with men's recent HIV-testing in rural Zambia this study, conducted in 2011–12, describes the HIV-testing behaviors of men aged 15–60 years in three contiguous rural districts. It identifies socio-demographic factors associated with self-reported HIV-testing behaviors and describes the proportion of men accepting an offer of rapid HIV-testing conducted as part of the research procedure for the study.

Methods

This study was a secondary analysis of baseline data collected for a cluster randomized stepped-wedge trial: the Better Health Outcomes through Mentoring and Assessment (BHOMA) trial [19]. BHOMA is being implemented in 42 clusters, defined as a health facility and its catchment area, across three districts in Lusaka, Zambia. The primary aims of BHOMA are to reduce age-adjusted all-cause and under-5 mortality [19]. Increasing HIV-testing is not a primary aim of BHOMA. Detailed information on the BHOMA intervention is described elsewhere [19]. The majority of the clusters are rural, with eight defined as peri-urban. Baseline data were collected from May 2011 to February 2012.

Cluster Demarcation

In each cluster, 120 randomly selected households were visited. Google Earth™ was used to demarcate a 3.8km radius around the health facilities. A 3.8km radius was used to minimize contamination [19]. The radius was then divided into squares of $900m^2$ containing fewer than 50 households. If a $900m^2$ square contained more than 50 households, the squares were divided into four smaller squares. Squares containing a minimum of five households were assigned numbers and computer-generated randomization used to determine which squares would be visited and the order of visitation. All households in randomly selected squares where the survey was started were visited until at least 120 households were enumerated in each cluster.

Data Collection

Data collection tools included: household enumeration forms, and household and individual questionnaires. Data were collected on a single household visit as data to estimate BHOMA's primary outcome, age-standardized mortality, were obtained from household enumeration. Repeat visits were not conducted if an individual household member was absent at the time of visit. Questionnaires were adapted from DHS and administered using personal digital assistants. Household questionnaires included questions on ownership of assets and time to travel to the health facility. All adults aged 15–60 years were eligible for participation in individual questionnaires, which included questions on demographics and personal health. After completion of questionnaires, individuals were offered rapid voluntary HIV-testing (Determine™ HIV-1/2) along-side other measurements, including height, weight, blood pressure and glucose level.

Statistical Analysis

All analyses were restricted to men with complete HTC history data (N = 2828). Outcomes were: i) a self-reported HIV-test (ever-testing), ii) an HIV test in the 12 months prior to the survey (recent-testing) and iii) accepting an offer of home-based HTC. Men were asked: ''Have you ever tested for HIV?'' Men who reported ever-testing were asked when they last tested for HIV. Socio-demographic characteristics investigated for their association with HIV-testing included age, religion, education, marital status and any history of TB-treatment (including current treatment). Pregnancy status of the wife, whether men had children and whether their wife had ever-tested for HIV were variables also investigated. Data on sexual behavior was not collected.

Household socioeconomic position (SEP) was also investigated for its association with all three outcomes. Principal components analysis (PCA) was used to develop an indicator of SEP. Household assets (Appendix 1) were coded as binary. To ensure variation in ownership, assets owned by >2% or <98% of households were retained for inclusion in PCA. Upon running the PCA, any variables whose weight did not reflect the expected direction would have been excluded, but none fulfilled that criterion. PCA was conducted on data from all enumerated households, regardless of whether an eligible man was present and without taking account of district or rural/peri-urban status. District, ART and cluster HIV-prevalence (using results of the rapid testing) were also investigated.

The distribution of individual- and household-level variables was compared between men reporting ever-testing and men reporting never-testing, and between men reporting a recent-test and men reporting never-testing. Characteristics of men who accepted the offer of home-based rapid HIV testing (HBHTC) were compared with individuals who declined HBHTC. Logistic regression models were fitted for ever- and recent-testing to examine their associations with individual-level variables and household SEP and allowing for between-cluster variability. All ever-testing models were age-adjusted. A random effect for geographical cluster was included. Factors significant at the 0.1 level were included in multivariable random effects logistic regression models. The reliability of the quadrature approximation was assessed after running each model. As all outcomes were common, prevalence ratios were presented. These were calculated using margins and *nlcom* commands in Stata 12.0.

It was hypothesized a priori that education might lie on the causal pathway between household SEP and HIV-testing, therefore SEP was explored in multivariable models that did not adjust for education. Final random effects logistic regression models were adjusted for cluster-level HIV-prevalence, ART availability and variations between the three districts by including these variables as fixed effects. The binary ART availability variable was obtained from the BHOMA health facility audit (conducted in 2011), which explored whether or not unexpired ART was available at each of the 42 facilities [20]. An interaction term was fitted between SEP and district to determine whether the effects of SEP differed by district.

The BHOMA study was approved by the University of Zambia Bioethics Committee, the London School of Hygiene and Tropical Medicine Ethics Committee and the institutional review boards at the University of Alabama at Birmingham (Birmingham, AL, USA), the University of North Carolina (Chapel Hill, NC, USA) [19]. All individuals were informed of the study objectives and asked for written informed consent.

Results

At baseline, 5725 households were visited of which 2% (n=127) refused to participate and 4% (n=225) were absent. In the 5373 consenting households, enumeration identified 6617 eligible men of whom 43% (n=2832) consented to participate. Fifty-seven percent (n=3785) were defined as non-responders, of whom 8% (n=299) were present but refused to participate and 92% (n=3486) were absent at the time of the visit (Fig. 1).

Complete data on age in years, SEP and district of residence were available for 87% (n=3289) of non-responders (Appendix 2, see Table 5). Age was missing for 13% (n=507) and SEP group for 1% (n=56) of non-responders. Men residing in Chongwe (adjusted prevalence ratio (APR): 0.89; 95% CI: 0.82–0.96; p<0.001) and Luangwa (APR: 0.80; 95% CI: 0.70–0.90; p<0.001) were less likely to be non-responders compared with men in Kafue, as were men aged ≥40 years compared with men aged 15–19 (APR: 0.75; 95% CI: 0.70–0.81; p<0.001). Men of highest SEP were more likely not to respond compared to men of lowest SEP (APR: 1.14; 95% CI: 1.04–1.24; p =0.001).

Baseline characteristics of the 2828 men with no missing HIV-testing data are presented in Table 1. Almost all (97%) had completed some primary education and 53% (n=1485) reported being married/cohabiting. Of the 1485 men who reported themselves as married or cohabiting, 60% (n=885) were linked to a spouse who participated in the BHOMA individual survey. All men linked to a spouse reported being married and 15% (n=130) had a pregnant partner (Table 1).

Self-Reported HIV-Testing

About half of all men (n=1480; 52%) reported ever-testing for HIV (Fig. 1). The number of men enumerated per cluster ranged from 40 to 94 (median: 69; IQR: 63–76). Mean prevalence of ever-testing varied by district (48% in Kafue, 49% in Chongwe, 70% in Luangwa; p<0.001). At cluster-level, the prevalence of ever HIV-testing ranged from 30% to 79% (median: 52%; IQR: 44–58%).

In multivariable analyses adjusted for individual-, spousal-, household- and community-level factors, individual-level factors retained strong associations with ever-testing (Table 1). Men aged 20–29 were more likely to test than men aged 15–19 (APR: 1.74; 95% CI: 1.49–1.99; p<0.001). Widowed men were almost twice as likely to report ever-testing compared with single men (APR: 1.76; 95% CI: 1.37–2.14; p <0.001). Among the 885 men linked to a spouse, men whose female partner reported ever-testing were more likely to report ever-testing compared with men whose wives never-tested (APR: 1.59; 95% CI: 1.27–1.90; p<0.001). Having children or a pregnant spouse were not associated with ever-testing.

HIV-prevalence and ART-availability were not associated with ever-testing. Men of highest SEP were more likely to report ever-testing compared with men of lowest SEP (APR: 1.25; 95% CI: 1.09–1.40; p=0.001). District was strongly associated with ever-testing, with men residing in Luangwa were more likely to report ever-testing (APR: 1.58; 95% CI: 1.37–1.78; p<0.001). There was no evidence of interaction between SEP and district for ever-testing (p=0.2). In final ever-testing models, the intra-cluster correlation coefficient (ICC) was 0.03 (95% CI: 0.01–0.06), with strong evidence of clustering (p<0.001).

Among all men, 25% (n=709) reported having a recent HIV-test. At cluster-level, ever- and recent-testing were strongly correlated (r=0.55; p<0.001; Fig. 2). Among men who reported ever-testing, 48% (n=709/1480) reported a recent-test. Excluding men with a history of ever-testing but no recent-test, 34% (n=709/2057) recently tested. At cluster-level, among all men the prevalence of recent-testing ranged from 11%-43% (median: 25%; IQR: 19–29%; Fig. 2).

Results for recent-testing were similar to those for ever-testing. In multivariable analyses, individual-level factors retained strong associations with recent-testing. Men with secondary education were more likely to report a recent-test compared with men with no education (APR: 1.87; 95% CI: 1.07–2.66; p<0.001; Table 2). Men with no religion were less likely to report recent-testing compared with Protestant men (APR: 0.46; 95% CI: 0.22–0.69; p = 0.002). Having a wife who reported ever-testing remained strongly associated with recent-testing (APR: 1.73; 95% CI: 1.17–2.29; p<0.001).Men of highest SEP were also more likely to report a recent-test compared with men of lowest SEP (APR: 1.43; 95% CI: 1.12–1.73; p=0.011) as were men residing in Luangwa (APR: 1.91; 95% CI: 1.52–2.31; p<0.001). There was no evidence of interaction between SEP and district for recent-testing (p=0.2).

Acceptance of an Offer of Home-Based HTC

Fifty-three percent (n=1499) of all men accepted the offer of HBHTC (Fig. 1). Among men who reported ever-testing and that they were HIV-negative but who did not report a recent HIV-test, 61% (n=404/658) accepted HBHTC of whom 4% (n=17/404) tested HIV-positive at this test. Of men who reported never-testing, 53% (n=714/1348) accepted HBHTC and 6% (n=43/714) tested HIV-positive. In multivariable analyses (Table 3), age was associated with accepting HBHTC with men aged 20–29 years more likely to accept HBHTC compared with men aged 15–19 (APR: 1.12; 95% CI: 0.99–1.24; p=0.01) and men aged ≥40 years less likely to accept HBHTC (APR: 0.95; 95% CI: 0.81–1.09; p=0.01). There was strong evidence that having no history of TB-treatment (APR: 0.76; 95% CI: 0.57–0.96; p=0.02) and weaker evidence that SEP were associated with HBHTC, with lower acceptance of HBHTC among men of highest SEP (APR: 0.87; 95% CI: 0.75–0.99; p=0.06). The offer of HBHTC decreased the proportion of men who never tested to 19% in the lowest SEP group compared to 27 % in the highest SEP group (Fig. 3). Men in Luangwa were more likely to accept HBHTC than men in Kafue (APR: 1.53; 95% CI: 1.24–1.83; p<0.001). There was no evidence of interaction between SEP group and district (p=1.0).

Discussion

This study adds to the limited available evidence of factors associated with different HIV-testing behaviors among rural Zambian men. In this study, self-reported ever HIV-testing by men in three districts was relatively high at 52 % compared with the 2007 Zambian DHS (22%), a community-based survey conducted in South and Central Province, Zambia, in 2010–2011 (36%) and other community-based surveys of HTC prevalence in Southern Africa [16, 21– 23]. Among men reporting ever-testing, approximately half had tested within the year preceding the survey. However, among all men regardless of testing history, only 25% reported testing recently. The individual-level factors predictive of ever-testing were also associated with recent-testing. These findings suggest that the recent introduction of strategies to increase population-levels of HIV-testing in Zambia, including PITC and ANC-based couples HTC [24– 27], may be failing to reach men with no history of HIV-testing (in particular younger and older men, men with less education and of lower SEP). Although the acceptance of an offer of home-based HTC was similar among men reporting no history of testing (53%) and ever-testers with no history of recent-testing (57%), the strategy offered an opportunity for never-testers of lower SEP and men who reported themselves as HIV-negative but did not report a recent test to learn their HIV status.

This study is subject to limitations. Firstly, nonresponse was high and limited socio-demographic data was available for non-responders. If non-responders are less likely to report HIV-testing the study may over-estimate ever- and recent-testing prevalence. Furthermore, due to self-selection, estimates of the associations between the factors of interest and HTC may be biased. For example, with men from Luangwa more likely to participate, the association between district and HTC may be biased. However, the factors found to be associated with HTC in this study are similar to those reported in others [11, 16, 21, 28]. Moreover, the results may not be generalizable to the target population. Secondly, with increased emphasis on the importance of knowing one's status men may have felt inclined to over-report testing behaviors due to social desirability bias. As the questionnaire from which the data arise focused on a range of health-related issues this bias might have been limited. Third, as this study is cross-sectional, causal links between variables of interest and HIV-testing cannot be confirmed. Fourth, the definition of cluster in this study may not capture factors that influence men's testing behaviors. In this study, cluster was defined as the health facility and its catchment area. Other definitions of cluster, such as district or men's social networks, may prove more predictive of testing behaviors. Finally, data on other factors known to be associated with HTC, including sexual behaviors, were not collected in this baseline questionnaire.

Similar to other studies, this study highlights that age was predictive of ever- and recent-HIV testing [21, 29]. In a rural South African study (2008), men aged 35–49 had four times the odds of testing compared with men aged 18–24 after adjusting for socioeconomic factors [21]. Conversely, in a 2010–2011 Zambian study, increasing age was independently associated with men not testing for HIV [16]. Similar findings were reported in Uganda in 2005, with men aged older than 35 years were less likely to test than younger men [15]. At the time of the BHOMA baseline study HTC was largely facility-based. Adolescents in rural contexts may face greater barriers to accessing HTC services than their urban counterparts, perhaps because of a lack of services that are adolescent-friendly and greater financial barriers [30]. However, the lower level of HIV-testing among younger men in this study may reflect perceived risk as younger men may be less likely to engage in risky sexual behavior [31]. In the absence of data on sexual behavior this cannot be verified. Nonetheless, as a gateway to HIV-prevention services, including voluntary medical male circumcision (VMMC) and condoms, an increased focus on age-appropriate HIV-testing interventions is required [8, 32, 33]. Since 2009, Zambia has scaled-up VMMC [34]. Among the services offered to men opting for VMMC is PITC. Reports from African countries highlight that the majority of service users are adolescents [35, 36]. The scale-up of VMMC, particularly mobile services in rural areas, may prove an important channel to providing younger males with access to HTC [8, 35]. As a unique opportunity to reach men [8], VMMC providers could promote the availability of HIV-testing within clinics to encourage men, beyond those intending to undergo circumcision, to test for HIV. Alternative strategies may, however, still be required to reach older men as a lower proportion reported recent-testing and accepted home-based testing [9].

Facility-based HTC provides opportunities to increase HTC among men already engaged with health services. In a study of PITC-implementation in primary healthcare clinics in urban Lusaka, 44% of the 31,197 individuals tested over 30 months were male [27]. In this study, a history of TB-treatment was strongly associated with HIV-testing (which remained when restricting analyses to HIV-negative men, data not shown). Although causality cannot be assessed, these findings suggest that PITC may be reaching men who access health facilities for other reasons. Couples HIV-testing is being scaled-up in Zambia, with pregnant women encouraged to bring their partners to ANC for HIV-testing [26, 37]. Studies from Zambia have shown, however, that male participation in ANC-based HTC is low [26]. Providing men with formal invitations through their pregnant partners and promotional campaigns may increase Zambian men's uptake of ANC-based HIV-testing [26, 38]. Nonetheless, men in this study setting were more likely to report testing if their spouse reported testing suggesting that ANC-based HTC can provide men with access to HTC services.

The finding that higher educational attainment and SEP were associated with prior HIV-testing is consistent with findings from earlier studies conducted in Ethiopia (2005) [14] and Uganda

(2005–2006) [15, 39], a study of men aged 18–32 years in an urban South African township (2007) and data from the 2002–2003 World Health Surveys [13, 15, 40]. The findings are also in line with the "inverse equity hypothesis", which proposes that individuals of higher SEP may benefit from new health interventions before individuals of lower SEP [41]. Community-based HTC aims to remove barriers to access including financial and opportunity costs associated with travelling to facilities. The expansion of HIV-testing services beyond health facilities may facilitate access to testing for individuals of lower SEP. In this study, acceptance of an offer of HBHTC was slightly higher amongst men of lower SEP who were more likely to be present at the time of visit. There was only weak evidence that this effect was significant. This finding is consistent with a study of HBHTC in rural Malawian villages [42]. Similarly, a study conducted in Zambia in 2003 found that offering home-based HTC to individuals initially expressing willingness to test reduced inequalities in ever-testing by educational attainment [10]. To facilitate HTC uptake by individuals with lower SEP and educational attainment, targeted HTC strategies may be required [40]. Furthermore, coverage by SEP and educational attainment should be monitored to support equitable access to HTC services [8].

There is little evidence of community-level factors that influence sub-Saharan African men's HIV testing [18]. An analysis of DHS data from eight African countries including the 2001–2 Zambian DHS highlights that in Zambia higher mean age of women at first birth, higher mean number of sexual partners and higher levels of male employment, among other community-level factors, are associated with married men's self-reported ever HIV-testing [18]. In this study, only three higher-level factors were explored. HIV-prevalence and the availability of ART at the local health facility were not associated with HIV-testing. The HIV-prevalence variable is likely to be subject to error due to low uptake of rapid HIV testing. Removing this variable from the analyses and including a variable based on self-reported HIV-status did not, however, affect the results (data not shown). Men residing in Luangwa were more likely to test than men in Chongwe or Kafue. This may reflect increased availability of alternate HTC service providers in Luangwa. Alternatively, with individuals in Luangwa more likely to be present, this association may be biased. In both ever- and recent-testing models, adjusting for district reduced cluster-level variance (data not shown). This suggests that some of the variation in HIV-testing is attributable to unobserved factors operating at the district-level. These may include promotion of services or availability of non-governmental HIV-testing service providers, which may have a greater influence on men's testing behaviors.

A systematic review of HBHTC highlights that men are as likely as women to be offered testing and to test for HIV when offered [6]. In some studies, however, the proportion of individuals found at home that were male was low [43]. In this study, a large proportion of men were absent at the time of the visit. Among men offered HBHTC, acceptance was similar to a longitudinal study in rural South Africa in 2003–2004 in which 56% of men consented to HBHTC [44]. However, uptake in this study was low compared to the pooled overall uptake reported in the HBHTC review (78.5%; 95% CI: 71–86%) and to a trial of HBHTC conducted in 2010 in 36 rural villages in Southern Zambia in which 64% (95% CI: 56.8–71.5%) of men offered HBHTC accepted testing [6, 9, 45]. The relatively low uptake may be explained by the fact that HTC was offered in a research setting where the priority was household enumeration and survey completion. Furthermore, repeat visits were not scheduled when men were absent. Nonetheless, offering HBHTC encouraged over half the never-testers to learn their HIV-status. Uptake was slightly higher amongst men with no history of TB-treatment suggesting that HBHTC may be effective at reaching men not engaged with available health services [6]. In particular, it may reach men of lower SEP. However, to achieve universal HIV-testing, providing home-based HIV-testing as the sole alternative to facility-based services may not suffice. Firstly, repeat visits are likely to be required to reach men, yet these may be logistically complex and/or may reduce the cost-effectiveness of the strategy to unacceptable levels [6, 28]. Secondly, despite removing barriers associated with uptake of facility-based HTC, a high proportion of non-testers refused HBHTC. Understanding why requires additional research to inform the implementation of future home-based HTC strategies. To reduce the costs associated with conducting home visits HBHTC could be combined with the delivery of other prevention interventions, which may also increase uptake of HTC [46].

Current HTC strategies are not yet reaching all men. To achieve universal HTC, as well as continuing to scale-up existing strategies, alternative approaches, such as mobile-testing, oral self-testing or workplace testing, may be required as these may prove more acceptable to men not accepting an offer of home-based HTC and not accessing facility-based services [7, 22, 47–49]. Mobile HIV-testing services reach a high number of men by providing services in locations and at times convenient to men [7]. Self-testing offers men the autonomy to test when and where they choose and removes barriers associated with provider-delivered HIV-testing [47] while workplace testing may prove convenient to men in formal employment, removing costs associated with seeking HIV-testing services during work hours [48]. An additional strategy that may increase men's HIV-testing and repeat-testing is financially or materially incentivized HIV-testing [50–52]. An incentivized ANC-based strategy that links men into HIV-testing following a female partner's test may prove effective and have a high impact if implemented at scale [53]. Prior to the implementation of an incentivized strategy, additional research on the model of service delivery, the type and level of incentives, cost-effectiveness, whether men with less education and of lower SEP are indeed being reached and any harms associated with such a strategy will be required [50, 54].

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Figure 1. Participants included in the study, their HIV-testing history and acceptance of HBHTC

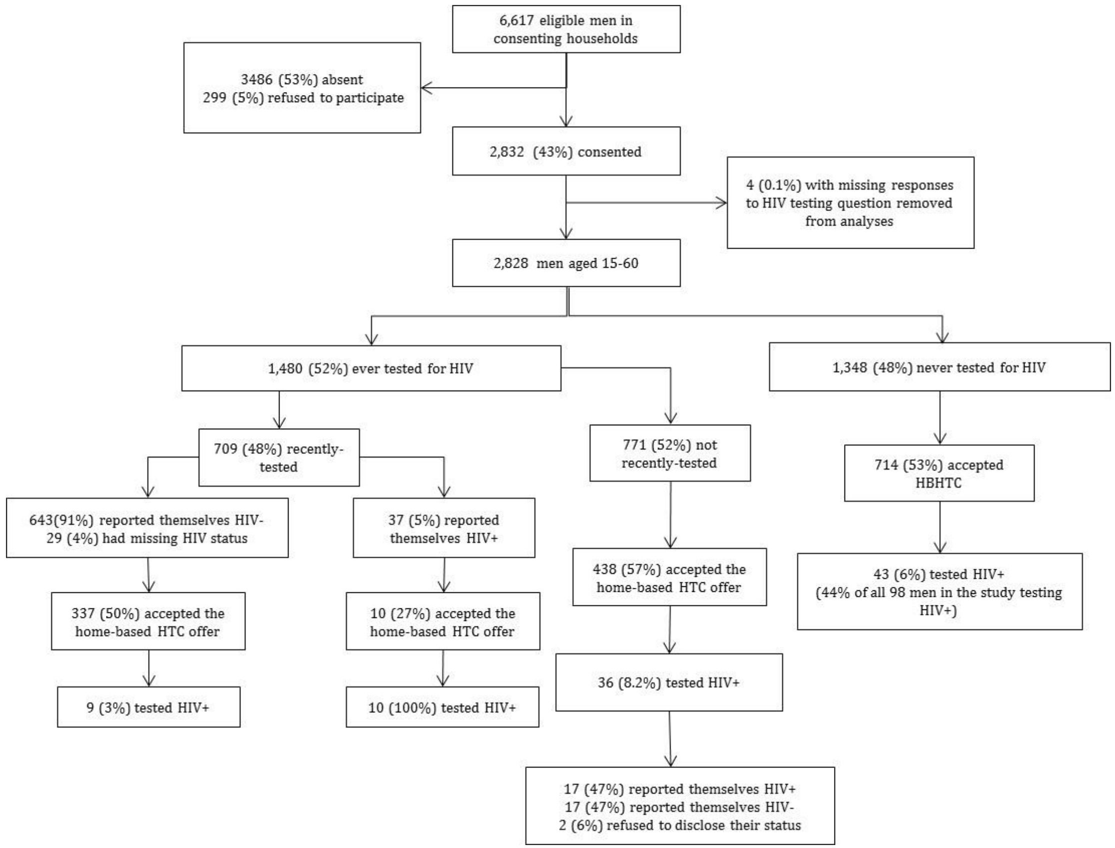


Figure 2. Cluster-level Recent-Testing versus Ever-Testing by District

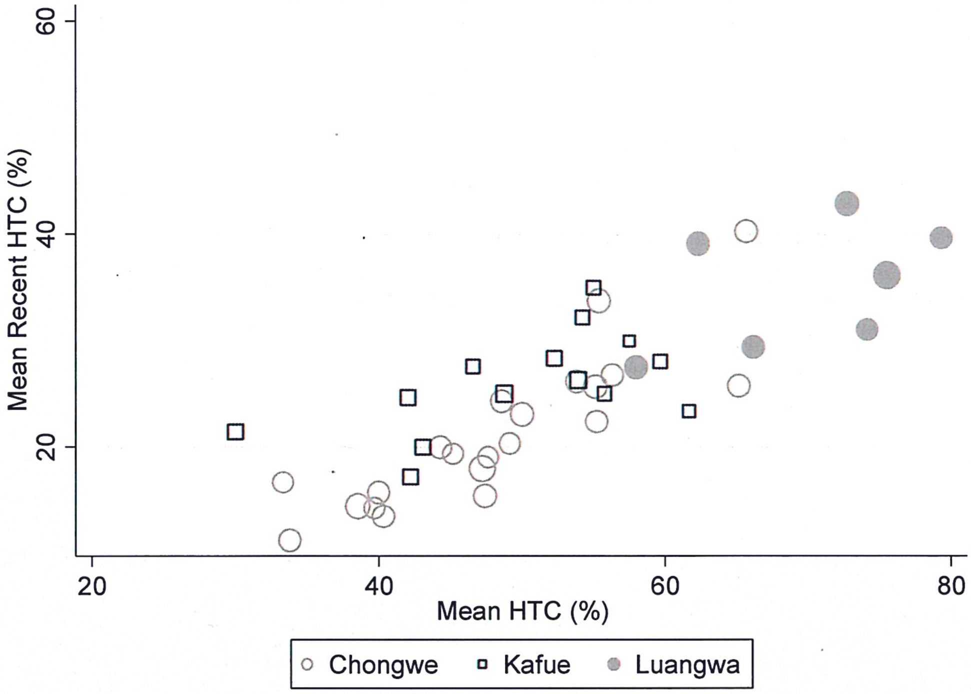


Table 1. Baseline Characteristics (N=2828) and Factors Associated with Ever Testing (N=2,769)

Individual-level Characteristic	Details	Baseline distribution (n, column %)	Ever Tested (n, row %)	Crude PR^ (95% CI)	Adjusted PR (95% CI)^^	p-value*
	All Men	2828	1480 (52.3)	-	-	-
Age#	15-19	605 (21.4)	173 (28.6)	1.0	1.0	<0.001
	20-29	831 (29.74)	496 (59.7)	2.29 (1.93, 2.65)	1.74 (1.49, 1.99)	
	30-39	681 (24.1)	424 (62.3)	2.39 (2.02, 2.78)	1.71 (1.42, 2.00)	
	≥40	705 (25.0)	384 (54.5)	2.09 (1.76, 2.42)	1.40 (1.14, 1.66)	
Education##	No Education	98 (3.5)	42 (42.9)	1.0	1.0	<0.001
	Primary	1,111 (39.3)	523 (47.1)	1.21 (0.90, 1.52)	1.18 (0.89, 1.47)	
	Secondary	1,617 (57.2)	914 (56.5)	1.54 (1.15, 1.94)	1.49 (1.13, 1.85)	
Religion###	Protestant	985 (35.1)	522 (53.0)	1.0	1.0	0.008
	Catholic	782 (27.9)	427 (54.6)	1.00 (0.91, 1.08)	0.97 (0.88, 1.05)	
	SDA	338 (12.0)	184 (54.4)	1.02 (0.91, 1.13)	1.02 (0.91, 1.12)	
	Other	604 (21.4)	299 (49.4)	0.91 (0.81, 1.00)	0.89 (0.80, 0.97)	
	None	93 (3.3)	38 (40.9)	0.64 (0.47, 0.82)	0.74 (0.56, 0.92)	
Marital Status	Single	1,199 (42.4)	481 (40.1)	1.0	1.0	<0.001
	Married/cohabiting	1,485 (52.5)	924 (62.2)	1.39 (1.23, 1.55)	1.41 (1.26, 1.57)	
	Separated/divorced	111 (3.9)	50 (45.0)	1.07 (0.83, 1.33)	1.06 (0.81, 1.31)	
	Widowed	33 (1.2)	25 (75.8)	1.77 (1.38, 2.16)	1.76 (1.37, 2.14)	
History of TB Treatment+	No	2,736 (96.8)	1,408 (51.5)	1.0	1.0	<0.001
	Yes	91 (3.2)	72 (79.1)	1.44 (1.26, 1.63)	1.48 (1.30, 1.66)	
Spouse Characteristics**						
Currently Pregnant ++	No	748 (85.2)	477 (63.8)	1.0	-	-
	Yes	130 (14.8)	91 (70.0)	1.05 (0.90, 1.20)		

Wife Reports having ≥1 Child	No	56 (6.3)	39 (69.6)	1.0	-	-
	Yes	829 (93.7)	534 (64.4)	0.98 (0.78, 1.17)		
Wife Previously HIV-tested [&]	No	149 (16.9)	56 (37.6)	1.0	1.0	<0.001
	Yes	735 (83.1)	516 (70.2)	1.71 (1.34, 2.08)	1.59 (1.27, 1.90)	
Household Characteristic						
SEP group* **	Poorest	471 (16.8)	240 (51.0)	1.0	1.0	0.001
	Poor	569 (20.3)	292 (51.3)	1.04 (0.90, 1.17)	1.01 (0.89, 1.14)	
	Middle	574 (20.5)	300 (52.3)	1.12 (0.98, 1.26)	1.11 (0.98, 1.24)	
	Wealthy	584 (20.8)	295 (50.5)	1.08 (0.94, 1.22)	1.07 (0.93, 1.20)	
	Wealthiest	604 (21.6)	336 (55.6)	1.26 (1.10, 1.43)	1.25 (1.09, 1.40)	
Community-level Factors						
HIV Prevalence	<10% (n=2239)	2,239 (79.2)	1,198 (53.5)	1.0	1.0	0.50
	>10% (n=589)	589 (20.8)	282 (47.9)	0.93 (0.76, 1.10)	0.96 (0.84, 1.08)	
ART at Local Health Facility	No	2,107 (74.5)	1,084 (51.4)	1.0	1.0	0.53
	Yes	721 (25.5)	396 (54.9)	1.09 (0.92, 1.26)	1.03 (0.92, 1.15)	
District	Kafue	864 (30.6)	427 (49.4)	1.0	1.0	<0.001
	Chongwe	1,471 (52.0)	709 (48.2)	0.99 (0.86, 1.11)	1.09 (0.94, 1.22)	
	Luangwa	493 (17.4)	344 (69.8)	1.45 (1.27, 1.64)	1.58 (1.37, 1.78)	

#6 missing; ## 2 missing; ###26 I don't know (DK) recoded as missing; +1 DK recoded as missing; ++7 DK recoded as missing; & 1 missing; ^Age-adjusted crude prevalence ratio (PR); ^^ Adjusted for all variables for which an adjusted PR is presented – ICC for adjusted model: 0.03 (95% CI: 0.01-0.06; p<0.001); * For adjusted model & based on LRT; ** N=864; ***26 missing & not adjusted for educational attainment in adjusted analyses N=2,771

Table 2. Distribution of Recent Testers (N=2,057) and Factors Associated with Recent Testing (N=2,017)

Individual-level Characteristic	Details	Recently Tested (n, row %)	Crude PR (95% CI)	Adjusted PR (95% CI)^	p-value*
	(N=2057)	709 (34.4)	-	-	-
Age	15-19	90 (17.2)	1.0	1.0	<0.001
	20-29	245 (42.2)	2.73 (2.11, 3.34)	2.02 (1.56, 2.47)	
	30-39	216 (45.7)	2.95 (2.27, 3.63)	2.00 (1.47, 2.53)	
	≥40	157 (32.9)	2.11 (1.60, 2.62)	1.37 (0.97, 1.77)	
Education	No Education	18 (24.3)	1.0	1.0	<0.001
	Primary	254 (30.2)	1.20 (0.68, 1.71)	1.39 (0.80, 1.98)	
	Secondary	437 (38.3)	1.59 (0.91, 2.26)	1.87 (1.07, 2.66)	
Religion	Protestant	262 (36.1)	1.0	1.0	0.002
	Catholic	187 (34.5)	0.90 (0.76, 1.05)	0.87 (0.74, 1.00)	
	SDA	92 (37.4)	1.03 (0.84, 1.22)	1.02 (0.84, 1.20)	
	Other	151 (33.1)	0.89 (0.74, 1.04)	0.86 (0.72, 0.99)	
	None	12 (17.9)	0.39 (0.17, 0.61)	0.46 (0.22, 0.69)	
Marital status	Single	242 (25.2)	1.0	1.0	<0.001
	Married/cohabiting	436 (43.7)	1.81 (1.56, 2.07)	1.57 (1.29, 1.85)	
	Separated/divorced	20 (24.7)	1.10 (0.66, 1.54)	0.92 (0.52, 1.32)	
	Widowed	11 (57.9)	2.54 (1.57, 3.51)	2.19 (1.33, 3.05)	
History of TB treatment	No	682 (33.9)	1.0	1.0	0.003
	Yes	27 (58.7)	1.75 (1.29, 2.20)	1.73 (1.32, 2.14)	
Spouse Characteristics**					
Currently pregnant	No	217 (44.5)	1.0	1.0	0.25
	Yes	51 (56.7)	1.26 (0.98, 1.54)	1.19 (0.93, 1.45)	
Wife Reports ≥1 Child	No	23 (57.5)	1.0	1.0	0.39
	Yes	247 (45.6)	0.76 (0.54, 0.98)	0.82 (0.57, 1.06)	
Wife previously HIV-tested	No	28 (23.1)	1.0	1.0	<0.001
	Yes	242 (52.5)	2.12 (1.37, 2.86)	1.73 (1.17, 2.29)	
Household Characteristic					
SEP group***	Poorest	109 (32.1)	1.0	1.0	0.011
	Poor	136 (32.9)	1.08 (0.84, 1.33)	1.07 (0.85, 1.30)	
	Middle	146 (34.8)	1.20 (0.93, 1.47)	1.21 (0.96, 1.47)	
	Wealthy	150 (34.2)	1.20 (0.93, 1.47)	1.19 (0.94, 1.44)	
	Wealthiest	162 (37.8)	1.35 (1.04, 1.66)	1.43 (1.12, 1.73)	
Cluster-level Factors					
HIV Prevalence	<10% (n=1633)	592 (36.3)	1.0	1.0	0.17
	>10% (n=424)	117 (27.6)	0.77 (0.55, 0.99)	0.86 (0.68, 1.05)	

ART Available at Health Facility	No	535 (34.3)	1.0	1.0	0.82
	Yes	174 (34.9)	1.04 (0.78, 1.30)	0.98 (0.80, 1.16)	
District	Kafue	223 (33.8)	1.0	1.0	<0.001
	Chongwe	312 (29.1)	0.85 (0.69, 1.01)	1.02 (0.81, 1.23)	
	Luangwa	174 (53.9)	1.59 (1.28, 1.90)	1.91 (1.52, 2.31)	

^Adjusted for all variables for which an adjusted PR is presented, N=2,017; * For adjusted model & based on LRT; **N=565; ***Not adjusted for educational attainment N=2,018; ICC adjusted model 0.03 (95%CI: 0.01-0.07; p<0.001)

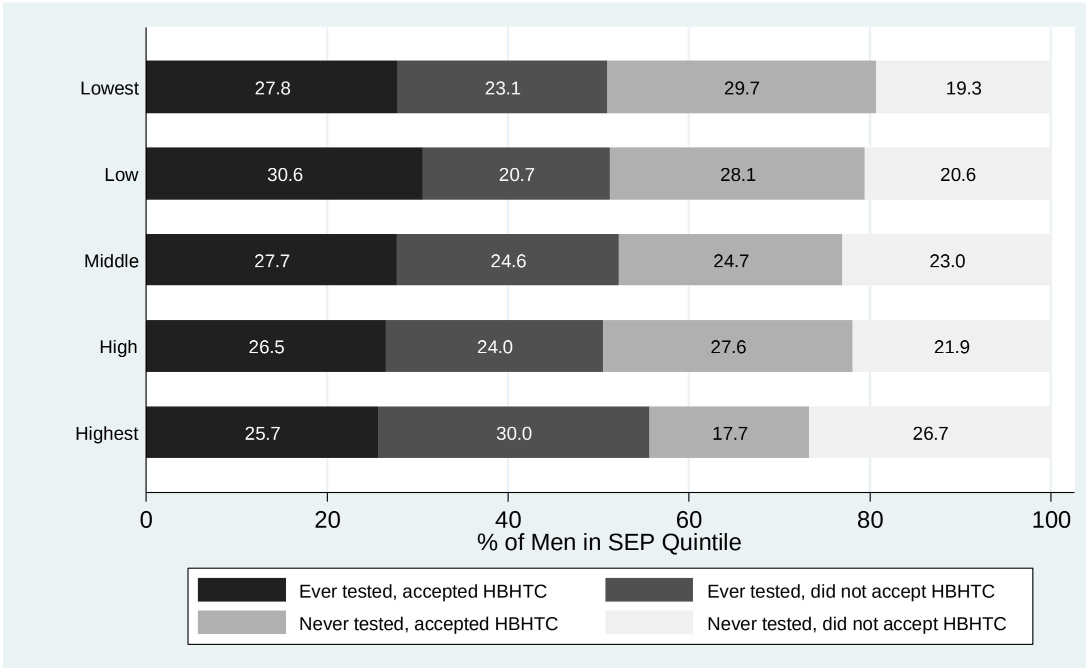
Table 3. Distribution of Uptake of HBHTC and Factors Associated with HBHTC Uptake (N=2828)

Individual-level Characteristic	Details	Accepted HBHTC (n, row %)	Uptake of HBHTC Crude PR (95% CI)	Adjusted PR (95% CI)^	p-value*
	All men (N=2828)	1499 (53.0)	-	-	-
Age	15-19	329 (54.4)	1.0	1.0	0.01
	20-29	476 (57.3)	1.09 (0.98, 1.20)	1.12 (0.99, 1.24)	
	30-39	353 (51.8)	0.97 (0.86, 1.08)	1.02 (0.88, 1.16)	
	≥40	338 (47.9)	0.88 (0.78, 0.99)	0.95 (0.81, 1.09)	
Education	No Education	52 (53.1)	1.0	1.0	0.08
	Primary	625 (56.3)	1.08 (0.85, 1.30)	1.08 (0.86, 1.31)	
	Secondary	820 (50.7)	0.99 (0.78, 1.20)	0.99 (0.79, 1.20)	
Religion	Protestant	515 (52.3)	1.0	-	-
	Catholic	426 (54.5)	1.00 (0.91, 1.10)		
	SDA	167 (49.3)	0.96 (0.83, 1.08)		
	Other	333 (55.0)	1.00 (0.90, 1.11)		
	None	47 (50.5)	0.91 (0.70, 1.12)		
Marital status	Single	666 (55.5)	1.0	1.0	0.35
	Married/cohabiting	761 (51.2)	0.90 (0.83, 0.97)	0.93 (0.83, 1.03)	
	Separated/divorced	58 (52.3)	0.99 (0.80, 1.17)	1.02 (0.82, 1.22)	
	Widowed	14 (42.4)	0.77 (0.45, 1.10)	0.83 (0.51, 1.16)	
History of TB treatment	No	1,464(53.5)	1.0	1.0	0.02
	Yes	35 (38.5)	0.74 (0.54, 0.93)	0.76 (0.57, 0.96)	
Spouse Characteristics					
Currently pregnant	No	407 (54.4)	1.0	-	-
	Yes	66 (50.8)	0.92 (0.75, 1.10)		
Wife Reports having ≥1 Child	No	29 (51.8)	1.0	-	-
	Yes	448 (54.0)	1.08 (0.77, 1.39)		
Wife previously HIV-tested	No	74 (49.7)	1.0	-	-
	Yes	403 (54.8)	1.11 (0.90, 1.32)		
Household Characteristic					
SEP group**	Poorest	271 (57.5)	1.0	1.0	0.06
	Poor	334 (58.7)	1.04 (0.92, 1.15)	1.03 (0.92, 1.15)	
	Middle	301 (52.4)	0.93 (0.82, 1.05)	0.95 (0.84, 1.07)	
	Wealthy	316 (54.1)	0.98 (0.87, 1.10)	1.01 (0.89, 1.12)	
	Wealthiest	262 (43.4)	0.83 (0.71, 0.94)	0.87 (0.75, 0.99)	
Community-level Characteristics					
HIV Prevalence	<10% (n=2239)	1,162(51.9)	1.0	1.0	0.47
	>10% (n=589)	337 (57.2)	1.10 (0.89, 1.32)	1.06 (0.90, 1.21)	

ART Available at Health Facility	No	1140 (54.1)	1.0	1.0	0.21
	Yes	359 (49.8)	0.92 (0.74, 1.11)	0.92 (0.78, 1.05)	
District	Kafue	348 (40.3)	1.0	1.0	<0.001
	Chongwe	848 (57.7)	1.46 (1.21, 1.71)	1.45 (1.20, 1.69)	
	Luangwa	303 (61.5)	1.57 (1.26-1.89)	1.53 (1.24, 1.83)	

^ Adjusted for all variables for which an adjusted PR is presented, N=2,793; * For adjusted model & based on LRT; ** Adjusted PR not adjusted for educational attainment n=2,795; ICC adjusted model 0.04 ((95%CI: 0.02-0.07); p<0.001)

Figure 3. Distribution of ever- and never-testers by SEP group after the offer of HBHTC



Appendix1.Table 4: Household Assets and Characteristics

No.	Variable*	%, n	95% CI**
1	Has one or more radios	54.8 (n=2946)	50.2, 59.4
2	Has one or more televisions	36.6 (n=1969)	30.6, 43.2
3	Has one or more mobile phones	71.6 (n=3844)	66.8, 76.1
4	Has one or more non-mobile phone	1.0 (n=52)*	0.6, 1.7
5	Has one or more beds	76.2 (n=4087)	71.5, 80.3
6	Has one or more chairs	41.7 (n=2232)	35.4, 48.2
7	Has one or more tables	56.6 (n=3043)	51.6, 61.5
8	Has one or more cupboards	32.6 (n=1748)	28.0, 37.5
9	Has one or more sofas	36.7 (n=1970)	30.4, 43.4
10	Has one or more clocks	19.6 (n=1053)	16.0, 23.8
11	Has one or more fans	8.2 (n=439)	5.2, 12.6
12	Has one or more sewing machines	6.4 (n=347)	5.2, 8.0
13	Has one or more ploughs	6.8 (n=367)	4.3, 10.7
14	Has one or more VCR/DVDs	23.1 (n=1242)	17.9, 29.4
15	Has one or more tractors	0.6 (n=30)*	0.4, 0.8
16	Has one or more cars	5.5 (n=298)	3.9, 7.8
17	Has one or more watches	9.0 (n=492)	7.6, 10.9
18	Has one or more bicycles	40.9 (n=2199)	36.7, 45.3
19	Has one or more motorcycles	0.7 (n=38)*	0.5, 1.0
20	Has one or more animal-drawn carts	3.3 (n=179)	2.1, 5.3
21	Has one or more boats	0.9 (n=51)*	0.5, 1.9
22	Has one or more fridges	12.3 (n=662)	7.8, 19.0
23	Has one or more grain grinders/hammer mills	0.9 (n=49)*	0.7, 1.2
Source of Drinking Water			
1	Piped water into dwelling/own yard	13.9 (n=746)	8.7, 21.5
2	Communal tap	15.2 (n=818)	9.7, 23.0
3	Open well/borehole	21.1 (n=1136)	15.5, 28.2
4	Covered or protected well/borehole	38.4 (n=2064)	30.2, 47.6
5	Spring/river/pond/lake/rain	10.3 (n=555)	5.9, 17.6
6	Other	0. 1 (n=53)	0. 4, 2.3
Toilet Facility			
1	Flush sewer system/septic tank/pit latrine/elsewhere	9.0 (n=481)	4.8, 16.1
2	VIP or latrine with/without slab	71.8 (n=3860)	65.5, 77.4
3	No facility/bush/field	17.6 (n=946)	13.0, 23.3
4	Other	1.6 (n=86)	1.0, 2.6
Type of Floor Material			

1	Natural	56.5 (n=3036)	47.8, 64.8
2	Finished	43.1 (n=2317)	34.9, 51.7
3	Other	0.3 (n=17)	0.2, 0.5
Type of External Walls			
1	Natural	42.6 (n=2291)	36.2, 49.3
2	Rudimentary	1.0 (n=55)	0.6, 1.7
3	Finished	55.8 (n=2997)	49.0, 62.3
4	Other	0.5 (n=29)	0.3, 1.0
Type of Roof Material			
1	Natural	36.1 (n=1937)	28.2, 44.7
2	Rudimentary	0.2 (n=9)	0.08, 0.3
3	Finished	63.7 (n=3425)	55.1, 71.6
4	Other	0.02 (n=2)	0.005, 0.3

*Variables not included in the PCA; ** Calculated using robust standard errors

Appendix 2

See Table 5.

Table 5 Distribution of 3785 non-responders among eligible men (N = 6617) and factors associated with non-response

Individual-level Characteristic	Details	Distribution of Non-Responders (n, row %)	Crude PR (95% CI)	Adjusted PR (95% CI)^	p-value for trend*
Age#	15-19	890 (59.2)	1.0	1.0	<0.001
	20-29	1037 (55.8)	0.93 (0.87-0.98)	0.93 (0.88-0.99)	
	30-39	781 (53.2)	0.88 (0.82-0.94)	0.89 (0.83-0.95)	
	≥40	570 (44.7)	0.75 (0.69-0.81)	0.75 (0.70-0.81)	
Age Category##	15-24	1568 (59.4)	1.0	1.0	0.002
	25-60	2217 (55.7)	0.93 (0.89-0.97)	0.93 (0.89-0.97)	
SEP group###	Poorest	536 (53.2)	1.0	1.0	0.001
	Poor	643 (52.9)	0.99 (0.91-1.07)	1.00 (0.91-1.08)	
	Middle	715 (55.5)	1.00 (0.92-1.08)	1.01 (0.93-1.10)	
	Wealthy	792 (57.6)	1.03 (0.95-1.11)	1.03 (0.95-1.12)	
	Wealthiest	1043 (63.3)	1.12 (1.03-1.20)	1.14 (1.04-1.24)	
District	Kafue	1484 (63.2)	1.0	1.0	<0.001
	Chongwe	1831 (55.4)	0.87 (0.81-0.94)	0.89 (0.82-0.96)	
	Luangwa	470 (48.7)	0.77 (0.67-0.86)	0.80 (0.70-0.90)	

#507 missing data; ##N=6535 in model adjusted for SEP and district; ###56 missing data; ^N=6033 adjusted for age, SEP and district; *Based on LRT test, ICC in adjusted model including actual age: 0.014 (95%CI: 0.007-0.027)

7.3 Chapter Summary

Men's levels of HIV-testing in the study sites increased between the 2011/12 and 2013 surveys and compared to the provincial estimate of ever-testing in the 2007 Zambian DHS (117). Nonetheless, some 40% of men report never-testing for HIV. Despite expanded availability and promotion of HTC services the factors associated with ever-testing in both surveys (Annex 4) remain similar to the factors associated with HIV testing prior to HTC service expansion. Having a spouse who reported ever-testing and a history of TB-treatment were strongly associated with ever-testing (26). Men with higher levels of education were more likely to ever- and recently-test relative to men with no or primary education. Younger men and men aged ≥40 were less likely to test and recently-test for HIV (26).

The offer of home-based HIV-testing in a research setting provided some 50% of all men an opportunity to test for HIV and of never-testers the opportunity to have their first HIV-test (26) (Annex 4). There was little evidence that any socio-demographic factors were associated with acceptance suggesting that home-based HIV-testing was equitable in its reach (26). In both surveys, some 40% of men testing HIV-positive during home-based HIV-testing had never HIV-tested (n=43 in 2011/12 and n=21 in 2013). Some 40% of these men were aged 30-39 years, just over half (51%) had primary education in the 2011/12 survey and 62% had incomplete secondary education. Almost one-third (30%) were of low SEP in 2011/12 and 48% were of low SEP in 2013. In both surveys, the majority of men were married (65% and 76%, respectively). In 2013, 38% of these men were employed in agricultural activities.

Chapter 8. Men's Frequency of HIV-testing and Factors Associated with Multiple HIV-testing

8.1 Preamble to Paper III: Frequency of HIV-testing and factors associated with multiple lifetime HIV-testing among a rural population of Zambian men

Annual HIV-testing among individuals at continued, high-risk of HIV infection is recommended in high prevalence settings (146). More frequent HIV-testing supports earlier diagnosis of individuals living with HIV. With the availability of alternate approaches to delivering HTC services, men's lifetime frequency of HIV-testing is expected to increase alongside an increase in levels of HIV-testing. A better understanding of men's frequency of HIV-testing is warranted. Investigating whether men who opt to test more frequently have similar characteristics to men who opt to test once is critical to informing the development of strategies to increase men's lifetime frequency of HIV-testing.

Research Paper III describes the frequency of HIV-testing among men in the study area and the characteristics associated with reporting multiple lifetime HIV-tests. The paper describes the acceptance of an offer of home-based HIV-testing among men with a history of HIV-testing to investigate whether offering home-based HIV-testing to men with a history of ever-testing increases the frequency of HIV-testing. The paper also investigates the factors associated with acceptance of an offer of home-based HIV-testing among these men.

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RESEARCH PAPER COVER SHEET

PLEASE NOTE THAT A COVER SHEET MUST BE COMPLETED FOR EACH RESEARCH PAPER INCLUDED IN A THESIS.

SECTION A – Student Details

Student	.Bernadette Hensen
Principal Supervisor	James Hargreaves
Thesis Title	Increasing men's uptake of HIV-testing in sub-Saharan Africa: a systematic review of interventions and analyses of population-based data from rural Zambia

If the Research Paper has previously been published please complete Section B, if not please move to Section C

SECTION B – Paper already published

Where was the work published?	BMC Public Health		
When was the work published?	Hensen B; Lewis JJ; Schaap A; Tembo M; Vera-Hernández M; Mutale W; Weiss HA; Hargreaves J; Stringer JSA; Ayles H		
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion			
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SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	
Please list the paper's authors in the intended authorship order:	
Stage of publication	Choose an item.

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I conceived the idea for the manuscript with James Hargreaves. I planned, with support from James Hargreaves and James Lewis, and conducted all analyses. I interpreted the findings and wrote the first draft of the manuscript. I responded to authors

	suggestions on the draft manuscript and to reviewers comments as appropriate.

Student Signature: BHansen **Date:** 19/01/16

Supervisor Signature: [signature] **Date:** 19/01/16

8.2 Research Paper III:

Frequency of HIV-testing and factors associated with multiple lifetime HIV-testing among a rural population of Zambian men

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Background: Across sub-Saharan Africa, men's levels of HIV-testing remain inadequate relative to women's. Men are less likely to access anti-retroviral therapy and experience higher levels of morbidity and mortality once initiated on treatment. More frequent HIV-testing by men at continued risk of HIV-infection is required to facilitate earlier diagnosis. This study explored the frequency of HIV-testing among a rural population of men and the factors associated with more frequent HIV-testing.

Methods: We conducted a secondary analysis of a population-based survey. Households (N=300) in randomly selected squares from 42 study sites, defined as a health facility and its catchment area, were invited to participate. Individuals in eligible households were invited to complete questionnaires regarding demographics and HIV-testing behaviours. Men were defined as multiple HIV-testers if they reported more than one lifetime test. Upon questionnaire completion individuals were offered rapid home-based HIV-testing. This study was conducted from February-November, 2013, in three rural district in Zambia.

Results: More than half (n=1459/2376; 61%) the men ever-tested for HIV. The median number of lifetime tests was 2 (interquartile range=1-3). More than half (n=834; 57%) of ever-testers were defined as multiple-testers. Relative to never-testers, multiple-testers had higher levels of education and were more likely to report an occupation. Among married men linked to a spouse, multiple-testing was higher among men whose spouse reported ever-testing (adjPR=3.02 95%CI: 1.37-4.66). Multiple-testing was higher in study sites where anti-retroviral therapy was at available the health facility on the day of a health facility audit. Among ever-testers, education and occupation were positively associated with multiple-testing relative to reporting one lifetime HIV-test. Almost half (49%) of ever-testers accepted the offer of home-based HIV-testing.

Conclusions: HIV-testing increased among this population of men since a 2011/12 survey. Yet, only 35% of all men reported multiple lifetime HIV-tests. The factors associated with multiple HIV-testing were similar to factors associated with ever-testing for HIV. Men living with HIV were less likely to report multiple HIV-tests and employment and education were associated with multiple-testing. The offer of home-based HIV-testing increased the frequency of HIV-testing among men. Strategies need to increase the lifetime frequency of HIV-testing among men at continued risk of HIV-infection.

Background

Annual HIV-testing and counselling (HTC) in high prevalence settings is recommended for individuals at continued risk of HIV infection to support early detection of HIV-infection and initiation of anti-retroviral therapy (ART) (1). Mathematical models suggest that the provision of "high-quality" HTC services to all individuals will increase the HIV-prevention impact of HTC service delivery (2). In settings where annual HTC is recommended, including Zambia, men's levels of ever HIV-testing remain lower than is needed to link men testing HIV-positive into care (3-5). Encouraging men to increase their lifetime frequency of HIV-testing may prove challenging (6).

Studies exploring risk factors for HIV-testing in sub-Saharan Africa highlight that age (3, 7-10), employment (4, 11), education (8, 10, 12) and socio-economic position (4, 12), marital status (8, 10), having heard of ART (4), community-level employment and HIV-knowledge (13) are associated with men ever-testing. Whether these factors also encourage men to test more frequently deserves exploration, to determine whether the expansion of HTC services has increased the frequency of HTC among men at risk of HIV-infection. Such evidence would support the development of strategies to reach men in need of annual HIV-testing.

This study describes the frequency of HIV-testing among a rural population of Zambian men and explores the factors associated with frequent HIV-testing. Among men with a history of ever HIV-testing, we hypothesized that men reporting frequent HIV-testing would differ in socio-demographic characteristics from men reporting one lifetime HIV-test. We also explore whether an offer of home-based HIV-testing in a research setting increases the frequency of testing among men with a history of HIV-testing.

Methods

We analyzed data collected for a stepped-wedge cluster randomized trial (CRT): the Better Health Outcomes through Mentoring and Assessment (BHOMA) trial, which aims to strengthen the healthcare system (14). Details of the intervention are published elsewhere (14, 15). Briefly, BHOMA was implemented in 42 clusters, defined as a health facility and its catchment area, in three districts in Lusaka Province, Zambia. BHOMA aims to reduce age-adjusted all-cause and under-5 mortality, and is being evaluated through 3 rounds of household surveys (14). Increasing HIV-testing is not a primary or secondary objective. However, health facilities were equipped with diagnostics and essential medicines (14), healthcare workers provided with protocols to guide adult visits alongside recruitment of community health workers to increase demand for health services (14). The majority of BHOMA study sites were rural (n=34, 81%). Data for the present analysis were from the mid-line evaluation (February-November, 2013) after intervention implementation in all sites.

In each cluster, squares of $900m^2$ were marked within a 3.8 kilometer of the health facility (3, 14). Computer-generated randomization was used to determine which squares would be visited and the order of visitation. All households in randomly selected squares where the survey was started were visited until 300 households were enumerated in each cluster.

Data Collection

Data collection tools included: household enumeration, and household and individual questionnaires. Due to financial constraints, households were either invited to complete a partial (household enumeration and questionnaire only) or full survey (household members asked to complete an individual questionnaire and offered measurements including blood glucose and pressure, and HIV-testing). Systematic random sampling was used to select households for participation in the full survey, with every 2.5th household offered the full survey (n=6788; 57%). Personal digital assistants (PDAs) informed research assistants which survey to offer a household prior to visitation. Data to estimate BHOMA's primary outcome were obtained from household enumeration Repeat visits were only conducted if entire households were absent. Questionnaires were adapted from Demographic and Health Surveys (DHS) and administered using PDAs. Household questionnaires included questions on asset ownership and housing material. Individuals aged 15-59 years were eligible for the individual questionnaire. After questionnaire completion, individuals were offered voluntary HIV-testing (Determine™ HIV-1/2).

Statistical Analysis

We restricted analyses to men. Outcomes of interest included: never-testing and ever-testing, defined as testing and receiving the result of an HIV-test, and multiple-testing. Men reporting >1 lifetime HIV-test were defined as multiple-testers. Ever-testers reporting one lifetime HIV-test were defined as one-time testers. Men self-reporting that they were living with HIV were defined as multiple-testers if their first HIV-test was before the test in which they received their HIV-positive diagnosis.

We described never- and ever-testing among men with complete data on variables of interest: age, religion, marital status, occupation, education, head of household, history of TB-treatment, ever HIV-tested and household socioeconomic position (SEP). Among ever-testers, we described the proportion reporting one and multiple HIV-tests. We described acceptance of home-based HIV-testing.

We described the distribution of the outcomes by socio-demographic characteristics, temporary migrancy (defined as being absent ≥1 month in the 6 months preceding the survey), and a history of TB-treatment. During household enumeration, females were asked what the number of their spouse was as listed on the enumeration form. Using this number, females were linked to their spouse. For men linked to a spouse who completed a questionnaire, we described outcomes by whether the spouse was pregnant, reported having children or ever HIV-tested. At cluster-level, we described outcomes by ART availability at the local health facility, HIV-prevalence, whether or not ≥50% of men reported employment and whether 25% of men listed 3+ ways to prevent HIV-infection.

Data on whether unexpired ART was available at health facilities was obtained from a health facility audit (conducted in 2012) (16). A household SEP indicator was developed using principal components analysis (PCA) (3). PCA was conducted on households with no missing data, regardless of whether households completed the full or partial survey, whether an eligible man was present and without taking account of district or rural/urban residence. SEP scores were divided into quintiles.

We estimated minimally-adjusted associations between independent variables and outcomes controlling for age, urban residence and a fixed effect for the three districts. Factors significant at the $p \leq 0.1$ level in minimally-adjusted models were included in multivariable models based on the framework in Figure 1. Socio-demographic factors were not adjusted for the more proximal factors likely to mediate their effect. Associations with community-level characteristics were estimated without adjustment for individual-level variables. Spousal characteristics were explored among the sub-set of men linked to a spouse. Multivariable models included a continuous variable for cluster size.

Insert Figure 1 here

We fit random effects logistic regression models in Stata 13.0 to adjust for geographic clustering. We checked the reliability of model estimates by running the *quadchk* command. For age, education and SEP we conducted a test assuming linear trend if there appeared to be a linear association. Due to the high prevalence of the outcomes, we estimated associations with prevalence ratios (PRs) using marginal standardization to estimate PRs, and the delta method to estimate 95% confidence intervals (95%CI). We used the likelihood ratio test (LRT) to estimate p-values.

Missing Data

Survey non-participation was high due to men being absent at the time of the household survey. We used Heckman-type selection models to investigate the null hypothesis that outcomes were "missing at random" conditional on covariates available for non-participants (17-19). We identified three variables that we theorized would be associated with survey participation but not HIV-testing: time (morning, afternoon, evening), day (Monday-Thursday, Friday, Saturday-Sunday) and season (rainy, cool/dry, hot/dry) of the survey. These variables were included in a random effects model controlling for variables crudely associated with participation to investigate whether they were independently associated with participation (Appendix 1) (18). Characteristics of eligible participants were randomly distributed by time but not day of the survey (Appendix 3). Time was entered in the model as a selection variable. Data available on non-participants and associated with HIV-testing in a 2011/12 survey (3) or theorized to be associated were included in the outcome model. We assessed evidence for the null hypothesis using rho and its p-value (18). Estimates of association between independent variables and outcome were obtained by adjusting for variables as described in Figure 1. Cluster-level variables were not adjusted for proximal factors. For multiple-testing, we investigated whether adjustment for variables included in the Heckman models affected estimates of association.

Ethics Statement

BHOMA was approved by the University of Zambia Bioethics Committee, the London School of Hygiene and Tropical Medicine Ethics Committee and the institutional review boards at the University of Alabama at Birmingham (Birmingham, AL, USA) and University of North Carolina (Chapel Hill, NC, USA) (14). Individuals were informed of the study objectives and asked for written informed consent. Consent was obtained from a parent/guardian for individuals aged 15-17 years.

Results

Sample Population

Of 5145 households invited to complete the full survey, 5144 consented. In these households, 6202 eligible men were enumerated of whom 29 did not have full data available and 376 were listed as absent in the month of or the month preceding the survey, leaving 5797 (93%) men defined as eligible to participate. Among these men, 42% (n=2463) participated (Figure 2). Participation ranged from 22% to 65% (median: 42%; inter-quartile range (IQR): 34%-51%) across study sites. Men of highest SEP were less likely to participate than men of lowest SEP (PR=0.74, 95%CI: 0.66-0.83; Appendix 1). Men listed as a household head were more likely to participate (PR=1.34 95%CI: 1.25-1.43).

Insert Figure 2 here

Frequency of HIV-testing

Among participating men, 37% (n=877/2376) reported never-testing for HIV, and 2% (n=40/2376) tested but never received the result of an HIV-test. Overall, 61% (n=1459) of men ever-tested. Ever-testing ranged from 44%-87% (median=62%; IQR=56%-67%) across study sites. Among ever-testers, 7% (n=98) reported themselves HIV-positive. The number of lifetime HIV-tests ranged from 1-25 (median=2; IQR=1-3).

Over half of ever-testers (57%; n=834/1459) were defined as multiple-testers (Figure 2). Among ever-testers, levels of multiple-testing were 62% in Kafue district and 55% in Chongwe and Luangwa. There was evidence for correlation between multiple-testing among ever-testers and ever-testing in Chongwe district (Chongwe r=0.54; p=0.01; Kafue r=0.05; p=0.86; Luangwa r=0.34; p=0.46; Figure 3). Multiple-testing ranged from 27% to 83% (median=57%; IQR: 48%-68%) across study sites and was clustered by study site (intra-cluster correlation coefficient (ICC)=0.05 95%CI: 0.03-0.11; p<0.01). Half (57%) the men living with HIV reported one-lifetime HIV-test. An estimated 14% HIV-tested prior to the test in which they received an HIV-positive diagnosis.

Insert Figure 3 here

The median numbers of years between first and most recent HIV-test was 2 (IQR: 1-4). Half (n=422; 51%) of multiple-testers and 29% (n=176) of one-time testers reported their first HIV-test between 2009 and 2011. Sixty-percent (n=504) of multiple-testers and 31% (n=191) of one-time testers tested within 12 months of the survey. Over half of one-time (n=341; 55%) and multiple-testers (n=498; 60%) reported their most recent HIV-test at the local health facility.

Factors associated with multiple HIV-testing

Relative to never-testers, multiple-testing was higher among men aged 30-39 relative to men 20-29 (65% vs 53%; adjPR=1.25 95%CI: 1.12-1.39; Table 1), men with complete secondary/higher education relative to men with no/primary education (65% vs 43%; adjPR=1.59 95%CI: 1.38-1.81) and among men reporting service/professional employment relative to men reporting no employment (70% vs 33%; adjPR=1.29 95%CI: 1.08-1.50; Table 1). Multiple-testing was higher among married/cohabiting men relative to single men (61% vs 32%; adjPR=1.23 95%CI: 1.03-1.43) and among Protestant men (52%) relative to men of no religion (33%; adjPR=0.69 95%CI: 0.47-0.90). There was weak evidence that men of middle SEP were more likely to report multiple-testing relative to men of lowest SEP (adjPR=1.19 95%CI: 1.02-1.37). Having a spouse who reported ever-testing was associated with multiple-testing (adjPR=3.02 95%CI: 1.37-4.66) with little evidence that having children was associated (p=0.20). There was little evidence that multiple-testing differed by cluster-level employment or HIV-knowledge. Multiple-testing was higher in sites where ART was available on the day of the audit (52% vs 43%; adjPR=1.29 95%CI: 1.12-1.45).

Insert Table 1 here

Relative to one-time testers, multiple-testers were less likely to be aged 15-19 (adjPR compared to 20-29: 0.63 95%CI: 0.49-0.77; Table 2). Among men working on their own land, 70% reported multiple-testing relative to 48% of men reporting no employment (adjPR=1.45 95%CI 1.27-1.63). There was little evidence of an association with marital status, a history of TB treatment or household SEP, with weak evidence that multiple-testing differed by being household head, pregnancy status of the spouse, or having children (Table 2). Men living with HIV were less likely to report multiple-tests prior to diagnosis (14% vs 61% among HIV-negative men; adjPR=0.22; 95%CI: 0.11-0.33). There was little evidence for an association with ART availability or cluster-level employment. Multiple-testing was lower in clusters with higher levels of HIV-prevention knowledge (53% vs 62%; adjPR =0.86 95%CI: 0.74-0.98).

Insert Table 2 here

Acceptance of an offer of home-based HIV-testing

Almost half of never- and ever-testers accepted the offer of home-based HIV-testing (48%; n=449 & 49%; n=719, respectively). Acceptance among ever-testers was clustered by study site (median: 48.0% IQR: 40.0%-54.7%; ICC=0.06 95%CI 0.03-0.11; p<0.01). Acceptance was similar among multiple- (n=422; 51%) and one-time testers (n=292; 47%; adjPR=1.05 95%CI: 0.93-1.17; Table 3). Among men reporting themselves HIV-negative or who did not know their HIV-status, 3% tested HIV-positive at this test.

Acceptance was lower among men aged ≥40 years relative to men aged 20-29 (42% vs 56%; adjPR=0.76; 95%CI: 0.65-0.87). There was little evidence that acceptance was associated with occupation, education, religion or marital status. Men present continuously in the 6 months preceding the survey were less likely to accept the offer relative to men with a period of being absent (adjPR=0.79 95%CI: 0.62-0.95) as were men whose spouse ever-tested (adjPR=0.66 95%CI: 0.50-0.81). Acceptance was lower among men listed as a household head (adjPR relative to men not a head=0.85 95%CI: 0.74-0.97) and among men of highest SEP (40%) relative to men of lowest SEP (54%; adjPR=0.82 95%CI: 0.64-1.01) with some evidence for a linear trend with SEP (p=0.14). There was little evidence that cluster-level employment, HIV-prevalence or ART availability were associated with acceptance. There was weak evidence that acceptance was higher in clusters with higher HIV-prevention knowledge (55% vs 43%; adjPR=1.12 95%CI: 0.95-1.30).

Insert Table 3 here

Heckman-Type Selection Modelling

Participation was somewhat higher among men visited on Saturday/Sunday (48%) relative to Monday-Thursday (41%) and among men visited in the afternoon (45%) relative to the morning (41%; adjPR=1.08 95%CI 1.01-1.14; (Appendix 2)). There was little evidence for unobserved factors influencing survey participation and HIV-testing outcomes (ever-testing: rho=-0.12 95%CI:-0.93 to 0.88; p=0.88; multiple-testing: rho=0.20 95%CI:-0.87 to 0.94; p=0.80) However, confidence intervals were very wide. Results were similar when day of the week was included in the selection models. Estimates of association between independent variables and multiple-testing were similar when adjusting for variables included in the Heckman-type selection model.

Discussion

In this large, population-based survey of predominantly rural men, 61% (95%CI: 58%-64%) of men were defined as ever-testers. Over half the men with a history of HIV-testing reported more than one lifetime HIV-test. Factors associated with multiple-testing were similar to factors associated with ever-testing (3, 8, 10, 12). The offer of home-based HIV-testing increased the lifetime frequency of HIV-testing among half of one-time and never-testers

Limitations of this study are that, as data were cross-sectional, temporal relationships cannot be inferred. Data were self-reported and collected retrospectively. Men may have over-reported HIV-testing and there are likely to be errors in recalling dates of HIV-tests. As a secondary analysis of data collected for an unrelated CRT, the study had limited capacity to explore whether men were HIV-testing annually as data were collected on years since first and most recent test, and number of HIV-tests. Nonetheless, most multiple-testers first tested in 2009 or later, suggesting that recent expansions of HTC services, including PITC, have increased men's frequency of HIV-testing. In the absence of data on sexual behaviours we had limited ability to explore whether multiple-testers were at increased risk of HIV-infection. However, we found that few men living with HIV reported HIV-testing prior to the test in which they received their diagnosis. However, we found that few men living with HIV reported HIV-testing prior to diagnosis. Although this measure is subject to limitations as multiple-testing was inferred from date of first HIV-test and of HIV-diagnosis, with almost 60% of HIV-positive men reporting one lifetime test, findings suggest that men continue to be diagnosed on their first test. Further exploration of multiple-testing behaviours alongside data on sexual behaviours is needed. Some 60% of married men were linked to their spouse; associations with spousal characteristics may be biased if characteristics of spouses linked differed from those not linked. Generalisability may be limited as the health system strengthening intervention, implemented in all sites at the time of data collection, may have contributed to increased frequency of HIV-testing.

Finally, outcomes were at risk of bias due to non-participation. Studies have shown that Heckman-type selection models can be used to correct HIV-prevalence estimates where refusal to HIV-test is high (18, 20). We used Heckman-models as we theorised that non-participation, largely due to absence, may be related to HIV-testing behaviours. The models suggested that there was no evidence for unobserved factors associated with participation and HIV-testing outcomes. However, we had limited ability to model selection due to limited individual-level data on non-participants. The selection variables were weak predictors of participation and may not be valid exclusion restrictions (21), as survey timing within clusters was not randomly determined. Aspects of survey conduct may independently affect outcomes (18); hence our estimates of correlation (rho) between outcome and participation had little precision.

Despite limitations, this study includes a large population of rural Zambian men whose multiple-testing behaviours have been understudied to date. The study provides important insights into the contribution of expanded HIV-testing service delivery to increasing men's lifetime frequency of HIV-testing.

To our knowledge, there are relatively few population-based surveys exploring the factors associated with multiple-testing. In a 2007 population-based survey conducted in communities in Soweto, South Africa, 50% of male ever-testers reported more than one lifetime test (4).

Multiple-testing was higher among individuals who had heard of ART (4). In our study, multiple-testing was higher in clusters where ART was available at the health facility suggesting that expanded ART availability contributes not only to ever-testing (22), but to increased frequency of HIV-testing. In South and Central Province, Zambia (2010/11), 36% of men ever-tested among whom 50% reported >1 lifetime HIV-test (23). In a 2012 nationally representative survey, 63% of Kenyan males aged 15-64 years ever-tested with a median of 3 tests (IQR: 2-4) per person (10).

By the time of this study, HIV-testing services had been expanded across Zambia, couples HTC was recommended in ANC and there was increased service promotion (24). Men whose spouse ever-tested were more likely to report multiple-tests. Similar to other settings, these findings suggest that HTC in ANC has provided men with access to HTC and may provide frequent access to HTC (12, 25). Yet, few men attend ANC (25). Considering the risk of HIV transmission among sero-discordant cohabiting/married couples, there remains a need to strengthen the delivery of HTC services to men through ANC (26-28).

Similar to a survey in South Africa, multiple-testers in this study were more likely to have complete secondary/higher education (4). Employed men in this study were more likely to report multiple HIV-tests unlike in South Africa (4). Formal employment may provide access to HTC services through the workplace thereby removing opportunity and financial costs of accessing facility-based HTC (29). Alternatively, employed men may be encouraged by their employer or motivated by their role as providers to access health services (30). Men of lower socioeconomic markers may face unique barriers to accessing HTC services that influence their frequency of HIV-testing. Lower health literacy likely contributes to lower levels of multiple-testing among men with less education. Other contributing factors, such as ability to access available services, stigma associated with HIV-testing within social networks or as experienced from healthcare workers, may also influence men's frequency of HIV-testing (31). Understanding why socioeconomic factors continue to influence men's HIV-testing behaviours in the context of expanded service availability, the need for regular HIV-testing by socioeconomic factors and how to encourage men with lower levels of education or no formal employment to regularly test for HIV needs exploration.

Evidence suggests that men continue to access care at later stages of HIV-infection (32). Regular-testing facilitates earlier diagnosis and opportunities to provide risk-reduction counselling to HIV-negative individuals at higher risk of infection. In a facility-based cohort in South Africa, repeat-testers were less likely to be HIV-infected relative to first-time testers (33). In Uganda, South Africa and Zimbabwe, studies found that individuals at lower risk of HIV were more likely to ever- or repeat-test (4, 12, 34). Conversely, in serological surveys in Tanzania, high-risk individuals were more likely to repeatedly accept VCT (35). In this study, 40% of ever-testers reported one-lifetime HIV-test and few men living with HIV-tested before their diagnoses. With investment in delivering community-based HTC (36), there is a need to monitor whether those in greatest need of annual HIV-testing are accessing services and the effects of frequent HIV-testing on sexual behaviours (37). Traditional "know your status" messaging may require reframing to emphasize the importance of annual HIV-testing if at ongoing risk of HIV-infection.

Home-based HIV-testing increased the lifetime frequency of HIV-testing among men in this study. As in other studies, there was little evidence that acceptance differed by markers of SEP (38, 39). The relatively high refusal in our study relative to others (3, 40) likely reflects service delivery in the context of research, where the priority was data collection, rather than the acceptability of a home-based HTC programme (3). In this study, multiple-testing was lower, but acceptance of home-based HIV-testing higher, in communities with higher HIV-prevention knowledge. These findings contribute to suggestions that poor accessibility influences men's uptake of HTC services (38, 41). Home-based HTC remains an important strategy to increase the frequency of HIV-testing among rural Zambian men with less access to services (3, 39). However, with most men not home during household visits, a cost-effective strategy for offering regular home-based HIV-testing in rural settings requires exploration (40).

Conclusion

Effective strategies to reach men with HTC services are available (28), and levels of ever-testing increased among this population of men (3). However, only 35% of all men reported multiple HIV-tests and few men living with HIV reported HIV-testing before being diagnosed. More effective implementation and delivery of available HTC services is required to reach men in need of more frequent HTC (41). Novel alternatives to encourage never-testers to access existing HTC services should be explored (28). These strategies could include self-testing and incentivised testing, shown to be acceptable and feasible among men (42-44). Additional research to investigate models for delivery, yield of these strategies and whether they are effective at increasing HIV-testing among HIV-negative men at high risk of infection is required (45, 46).

Competing Interests

The authors declare that they have no competing interests.

Author Contributions

BH conceived the study, conducted the analyses, interpreted the data and drafted the first manuscript. JH conceived the study, advised on data analyses and made original text contributions. JL and HW participated in data interpretation and made original text contributions during the drafting process. JL also provided guidance on data analyses. AS, MT and WM participated in data acquisition and preparation for analyses. MvH participated in the Heckman analyses and the interpretation of these findings. JS and HA conceived and designed the CRT and made original text contributions All authors provided critical revisions to the manuscript and approved the final draft.

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Figure 1. Framework illustrating the expected relationship between factors explored for their association with HIV-testing outcomes

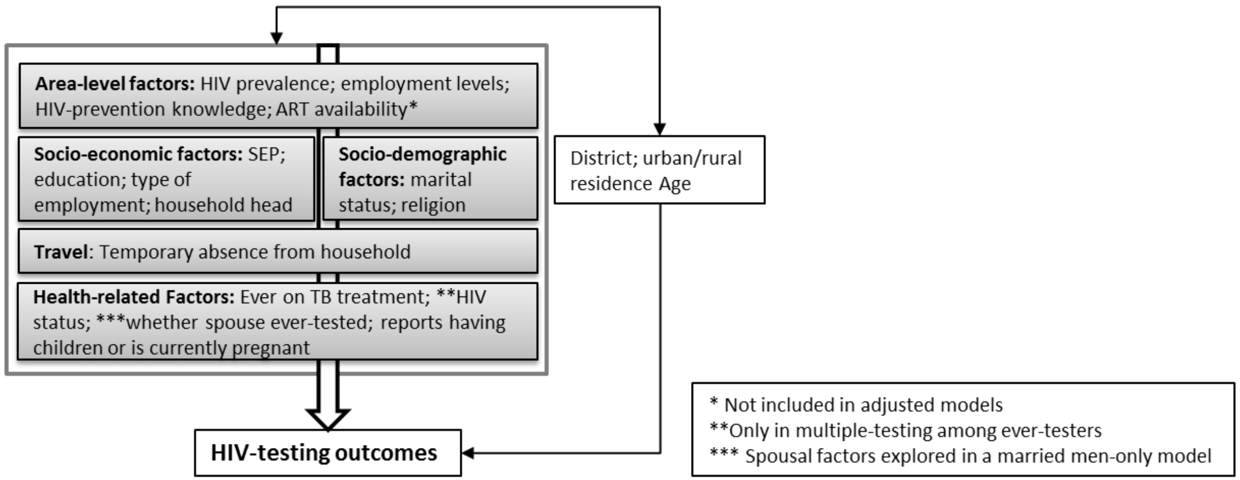

Figure 2. Flow diagram of study participation and frequency of HIV-testing

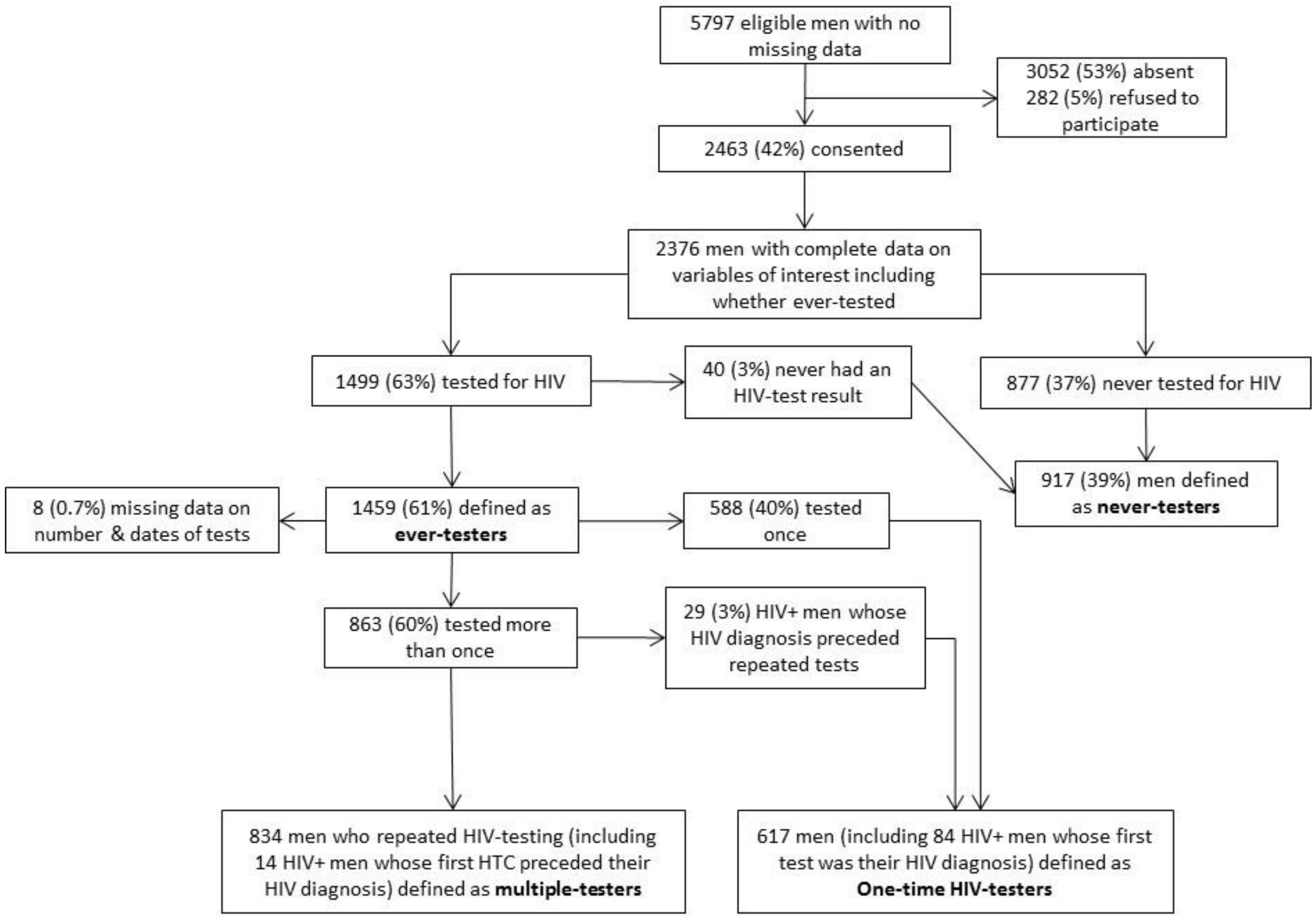

Figure 3. Scatter plot of correlation between multiple-testing among ever-testers and ever-testing at cluster-level

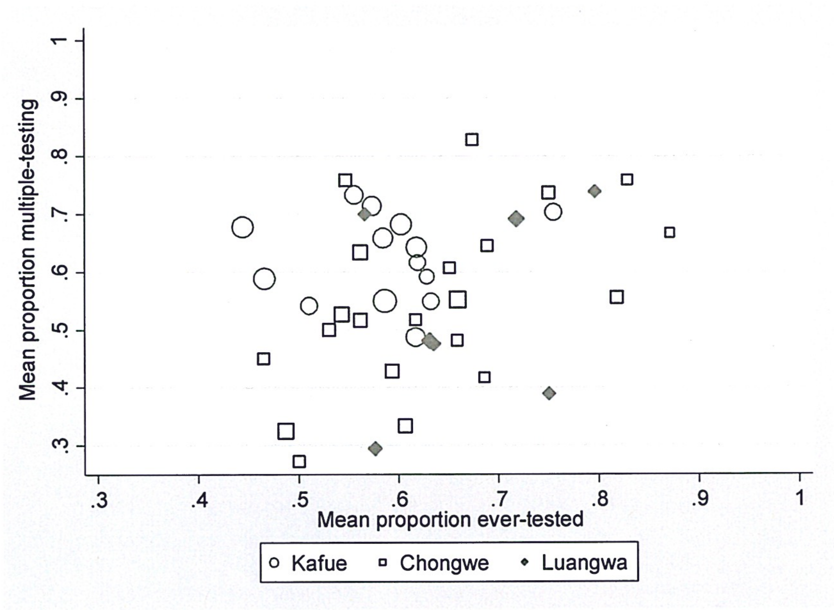

Table 1. Distribution of characteristics by never- and multiple-testers and factors associated with multiple HIV-testing relative to never-testers (N=1751)

	Details	Multiple-testers & never-testers (n, col %)	Never-Testers (n, row %)	Multiple Testers (n, row %)	Minimally-adjusted PR (95%CI)[2]	Adjusted PR (95%CI)[3]	p-value[4]
Age	15-19	387 (22.1)	328 (84.8)	59 (15.2)	0.28 (0.21-0.36)	0.29 (0.22-0.37)	
	20-29	553 (31.6)	259 (46.8)	294 (53.2)	1.0	1.0	<0.01
	30-39	391 (22.3)	137 (35.0)	254 (65.0)	1.23 (1.09-1.36)	1.25 (1.12-1.39)	(<0.01)
	≥40	420 (24.0)	193 (46.0)	227 (54.0)	1.02 (0.89-1.14)	1.04 (0.91-1.16)	
Head of household	No	680 (38.8)	472 (69.4)	208 (30.6)	1.0	1.0	0.06
	Yes	1071 (61.2)	445 (41.5)	626 (58.5)	1.28 (1.09-1.46)	1.15 (0.97-1.32)	
Religion	Protestant	684 (39.1)	332 (48.5)	352 (51.5)	1.0	1.0	
	Catholic	435 (24.8)	229 (52.6)	206 (47.4)	0.89 (0.78-1.00)	0.91 (0.80-1.01)	
	SDA	257 (14.7)	122 (47.5)	135 (52.5)	1.01 (0.88-1.15)	0.98 (0.85-1.11)	0.01
	Other	305 (17.4)	187 (61.3)	118 (38.7)	0.78 (0.66-0.90)	0.83 (0.71-0.96)	
	None	70 (4.0)	47 (67.1)	23 (32.9)	0.59 (0.38-0.79)	0.69 (0.47-0.90)	
Marital status	Single	762 (43.5)	522 (68.5)	240 (31.5)	1.0	1.0	
	Married/cohabiting	913 (52.1)	361 (39.5)	552 (60.5)	1.33 (1.12-1.53)	1.23 (1.03-1.43)	0.02
	Ever married	76 (4.3)	34 (44.7)	42 (55.3)	1.26 (0.94-1.59)	1.30 (0.99-1.61)	
Education	No/Primary	745 (42.5)	426 (57.2)	319 (42.8)	1.0	1.0	<0.01
	Incomplete secondary	649 (37.1)	366 (56.4)	283 (43.6)	1.29 (1.13-1.44)	1.26 (1.11-1.40)	(<0.01)
	Secondary or higher	357 (20.4)	125 (35.0)	232 (65.0)	1.61 (1.41-1.81)	1.59 (1.38-1.81)	
Occupation	None	802 (45.8)	536 (66.8)	266 (33.2)	1.0	1.0	
	Agriculture (others land)	378 (21.6)	182 (48.1)	196 (51.9)	1.17 (0.99-1.34)	1.11 (0.94-1.27)	<0.01
	Agriculture (own land)	357 (20.4)	134 (37.5)	223 (62.5)	1.39 (1.19-1.60)	1.30 (1.11-1.48)	
	Services/Professional	214 (12.2)	65 (30.4)	149 (69.6)	1.53 (1.30-1.77)	1.29 (1.08-1.50)	

SEP Group	Lowest	343 (19.6)	184 (53.6)	159 (46.4)	1.0	1.0	
	Low	331 (18.9)	188 (56.8)	143 (43.2)	1.01 (0.83-1.18)	0.99 (0.93-1.14)	
	Middle	365 (20.8)	179 (49.0)	186 (51.0)	1.24 (1.03-1.44)	1.19 (1.02-1.37)	0.06
	High	361 (20.6)	189 (52.4)	172 (47.6)	1.21 (1.01-1.42)	1.09 (0.92-1.26)	
	Highest	351 (20.0)	177 (50.4)	174 (49.6)	1.32 (1.08-1.55)	1.04 (0.84-1.25)	
Present continuously previous 6mths	No	87 (5.0)	50 (57.5)	37 (42.5)	1.0	-	-
	Yes	1664 (95.0)	867 (52.1)	797 (47.9)	1.12 (0.85-1.40)		
History of TB treatment	No	1702 (97.2)	899 (52.8)	803 (47.2)	1.0	-	-
	Yes	49 (2.8)	18 (36.7)	31 (63.3)	1.15 (0.88-1.43)		
Spousal Characteristics (N=511)							
Currently pregnant	No	447 (87.6)	179 (40.0)	268 (60.0)	1.0	-	-
	Yes	63 (12.4)	19 (30.2)	44 (69.8)	1.16 (0.95-1.38)		
Has Children	No	27 (5.3)	14 (51.9)	13 (48.2)	1.0	1.0	0.20
	Yes	483 (94.7)	183 (37.9)	300 (62.1)	1.34 (0.76-1.91)	1.26 (0.76-1.76)	
Wife previously HIV-tested	No	56 (11.0)	46 (82.1)	10 (17.9)	1.0	1.0	<0.01
	Yes	454 (89.0	151 (33.3)	303 (66.7)	3.53 (1.50-5.57)	3.02 (1.37-4.66)	
Cluster-level Characteristics							
>50% of men employed	No	684 (39.1)	379 (55.4)	305 (44.6)	1.0	-	-
	Yes	1067 (60.9)	538 (50.4)	529 (49.6)	1.10 (0.91-1.29)		
>25% mention 3+ ways to prevent HIV infection	No	878 (50.1)	435 (49.5)	443 (50.5)	1.0	-	-
	Yes	873 (49.9)	482 (55.2)	391 (44.8)	0.90 (0.76-1.04)		
HIV Prevalence	<10%	1381 (78.9)	704 (51.0)	677 (49.0)	1.0	1.0	0.14
	10%+	370 (21.1)	213 (57.6)	157 (42.4)	0.87 (0.70-1.03)	0.87 (0.70-1.04)	
ART Available at Health Facility1	No	858 (51.8)	491 (57.2)	367 (42.8)	1.0	1.0	<0.01
	Yes	799 (48.2)	381 (47.7)	418 (52.3)	1.30 (1.12-1.48)	1.29 (1.12-1.45)	

Key: [1] 94 missing data N=1657; [2] Adjusted for age, urban/rural residence and district; [3] Adjusted for variables higher in the conceptual framework (Figure 1); [4]For adjusted model and based on LRT, p-value in brackets is assuming linear trend;

Table 2. Distribution of characteristics by one- and multiple-testers and factors associated with multiple HIV-testing relative to one-time testers (N=1451)

	Details	Men with a history of ever-testing	One-time Testers (n, row %)	Multiple Testers (n, row %)	Minimally-adjusted PR (95%CI)[2]	Adjusted PR (95%CI)[3]	p-value[4]
Age	15-19	159 (11.0)	100 (62.9)	59 (37.1)	0.62 (0.48-0.76)	0.63 (0.49-0.77)	<0.01 (0.03)
	20-29	489 (33.7)	195 (39.9)	294 (60.1)	1.0	1.0	
	30-39	405 (27.9)	151 (37.3)	254 (62.7)	1.06 (0.95-1.18)	1.05 (0.94-1.16)	
	≥40	398 (27.4)	171 (43.0)	227 (57.0)	0.95 (0.84-1.06)	0.95 (0.84-1.06)	
Head of household	No	424 (29.2)	216 (50.9)	208 (49.1)	1.0	1.0	0.06
	Yes	1027 (70.8)	401 (39.0)	626 (61.0)	1.15 (1.00-1.30)	1.13 (0.98-1.28)	
Religion	Protestant	575 (39.6)	223 (38.8)	352 (61.2)	1.0	1.0	0.15
	Catholic	386 (26.6)	180 (46.6)	206 (53.4)	0.87 (0.77-0.98)	0.89 (0.79-0.99)	
	SDA	235 (16.2)	100 (42.6)	135 (57.4)	0.90 (0.78-1.03)	0.89 (0.77-1.01)	
	Other	208 (14.3)	90 (43.3)	118 (56.7)	0.92 (0.79-1.05)	0.99 (0.86-1.11)	
	None	47 (3.2)	24 (51.1)	23 (48.9)	0.78 (0.54-1.02)	0.86 (0.62-1.09)	
Marital status	Single	475 (32.7)	235 (49.5)	240 (50.5)	1.0	-	-
	Married/cohabiting	905 (62.4)	353 (39.0)	552 (61.0)	1.15 (0.99-1.31)		
	Ever married	71 (4.9)	29 (40.8)	42 (59.2)	1.13 (0.87-1.40)		
Education	No/Primary	589 (40.6)	270 (45.8)	319 (54.2)	1.0	1.0	<0.01 (<0.01)
	Incomplete secondary	515 (35.5)	232 (45.0)	283 (55.0)	1.08 (0.96-1.21)	1.11 (0.99-1.24)	
	Secondary or higher	347 (23.9)	115 (33.1)	232 (66.9)	1.26 (1.11-1.41)	1.29 (1.13-1.44)	
Occupation	None	555 (38.2)	289 (52.1)	266 (47.9)	1.0	1.0	<0.01
	Agriculture (others land)	351 (24.2)	155 (44.2)	196 (55.8)	1.11 (0.96-1.27)	1.10 (0.95-1.26)	
	Agriculture (own land)	320 (22.1)	97 (30.3)	223 (69.7)	1.46 (1.28-1.65)	1.45 (1.27-1.63)	
	Services/Professional	225 (15.5)	76 (33.8)	149 (66.2)	1.27 (1.09-1.46)	1.19 (1.00-1.37)	
SEP Group	Lowest	263 (18.1)	104 (39.5)	159 (60.5)	1.0	-	-
	Low	264 (18.2)	121 (45.8)	143 (54.2)	0.91 (0.77-1.04)		
	Middle	336 (23.2)	150 (44.6)	186 (55.4)	0.90 (0.77-1.04)		
	High	311 (21.4)	139 (44.7)	172 (55.3)	0.92 (0.78-1.06)		
	Highest	277 (19.1)	103 (37.2)	174 (62.8)	1.05 (0.88-1.21)		

Present continuously previous 6mths	No Yes	60 (4.1) 1391 (95.9)	23 (38.3) 594 (42.7)	37 (61.7) 797 (57.3)	1.0 0.91 (0.72-1.09)	-	-
History of TB treatment	No Yes	1383 (95.3) 68 (4.7)	580 (41.9) 37 (54.4)	803 (58.1) 31 (45.6)	1.0 0.76 (0.55-0.97)	1.0 1.06 (0.84-1.28)	0.62
HIV Status	Negative Positive	1297 (93.0) 98 (7.0)	507 (39.1) 84 (85.7)	790 (60.9) 14 (14.3)	1.0 0.20 (0.10-0.31)	1.0 0.22 (0.11-0.33)	<0.01
Spousal Characteristics (N=517)							
Currently pregnant	No Yes	443 (85.7) 74 (14.3)	175 (39.5) 30 (40.5)	268 (60.5) 44 (59.5)	1.0 0.97 (0.77-1.17)	-	-
Has Children	No Yes	20 (3.9) 497 (96.1)	7 (35.0) 198 (39.8)	13 (65.0) 299 (60.2)	1.0 0.93 (0.60-1.26)	-	-
Wife previously HIV-tested	No Yes	24 (4.6) 493 (95.4)	14 (58.3) 191 (38.7)	10 (41.7) 303 (61.3)	1.0 1.44 (0.75-2.12)	1.0 1.19 (0.73-1.66)	0.32
Cluster-level Characteristics							
>50% of men employed	No Yes	578 (39.8) 873 (60.2)	273 (47.2) 344 (39.4)	305 (52.8) 529 (60.6)	1.0 1.15 (0.97-1.34)	1.0 1.09 (0.92-1.25)	0.29
>25% mention 3+ ways to prevent HIV infection	No Yes	711 (49.0) 740 (51.0)	268 (37.7) 349 (47.2)	443 (62.3) 391 (52.8)	1.0 0.84 (0.72-0.95)	1.0 0.86 (0.74-0.98)	0.05
HIV Prevalence	<10% 10%+	1160 (79.9) 291 (20.1)	483 (41.6) 134 (46.0)	677 (58.4) 157 (54.0)	1.0 0.96 (0.79-1.13)	-	-
ART Available at Health Facility[1]	No Yes	676 (49.3) 694 (50.7)	309 (45.7) 276 (39.8)	367 (54.3) 418 (60.2)	1.0 1.09 (0.95-1.24)	-	-

Key: [1] 81 missing data N=1370; [2] Adjusted for age, urban/rural residence and district; [3] Adjusted for variables higher in the conceptual framework (Figure 1); [4] For adjusted model and based on LRT, p-value in brackets is assuming linear trend

Table 3. Acceptance of an offer of home-based HIV-testing by socio-demographic characteristics and factors associated with acceptance among ever-testers (N=1459)

	Details	Distribution (n, col%)	HBHTC (n, row %)	Minimally-Adjusted PR (95%CI) 3	Adjusted PR (95% CI)4	p-value5
	Ever tested	N=1459	719 (49.0)	-	-	-
Age	15-19	159 (10.9)	89 (56.0)	0.98 (0.82-1.14)	0.97 (0.81-1.14)	0.01 (<0.01)
	20-29	492 (33.7)	272 (55.6)	1.0	1.0	
	30-39	408 (28.0)	187 (46.2)	0.83 (0.72-0.95)	0.84 (0.73-0.95)	
	≥40	400 (27.4)	166 (41.7)	0.75 (0.65-0.86)	0.76 (0.65-0.87)	
Household Head	No	425 (29.1)	239 (56.2)	1.0	1.0	0.02
	Yes	1034 (70.9)	480 (46.4)	0.88 (0.76-1.00)	0.85 (0.74-0.97)	
Education	None/primary	591 (40.5)	285 (48.4)	1.0	1.0	0.32
	Some secondary	517 (35.4)	274 (53.2)	1.05 (0.92-1.18)	1.05 (0.92-1.19)	
	Complete secondary/higher	351 (24.1)	155 (44.7)	0.89 (0.76-1.03)	0.94 (0.79-1.10)	
Occupation	None	557 (38.2)	298 (53.7)	1.0	-	-
	Agriculture (others land)	352 (24.1)	170 (48.4)	0.98 (0.84-1.12)		
	Agriculture (own land)	322 (22.1)	150 (46.9)	0.95 (0.80-1.10)		
	Services/Professional	228 (15.6)	96 (42.7)	0.85 (0.70-1.00)		
Religion	Protestant	577 (40.0)	267 (46.4)	1.0	-	-
	Catholic	390 (26.7)	204 (52.8)	1.06 (0.92-1.20)		
	SDA	235 (16.1)	107 (45.5)	0.96 (0.80-1.12)		
	Other	210 (14.4)	112 (53.8)	1.08 (0.91-1.25)		
	None	47 (3.2)	24 (51.1)	1.03 (0.71-1.34)		
Marital status	Single	477 (32.7)	259 (54.5)	1.0	-	-
	Married/cohabiting	910 (62.4)	419 (46.3)	0.96 (0.81-1.10)		
	Ever married	72 (4.9)	36 (50.7)	1.12 (0.85-1.40)		
Household SEP Group	Lowest	264 (18.1)	143 (54.4)	1.0	1.0	0.29 (0.13)
	Low	265 (18.2)	137 (51.9)	1.01 (0.84-1.18)	1.00 (0.83-1.18)	
	Middle	337 (23.1)	172 (51.2)	1.02 (0.85-1.18)	1.01 (0.84-1.17)	
	High	313 (21.5)	150 (48.2)	0.98 (0.81-1.15)	0.97 (0.80-1.14)	
	Highest	280 (19.2)	112 (40.4)	0.81 (0.64-0.99)	0.82 (0.64-1.01)	

Present continuously previous 6mths	No Yes	60 (4.1) 1399 (95.9)	38 (63.3) 676 (48.6)	1.0 0.79 (0.62-0.96)	1.0 0.79 (0.62-0.95)	0.04
History of TB treatment1	No Yes	1391 (95.3) 68 (4.7)	689 (49.8) 25 (36.8)	1.0 0.80 (0.56-1.04)	1.0 0.95 (0.68-1.21)	0.71
HIV status1	Negative Positive	1305 (93.0) 98 (7.0)	675 (51.7) 21 (21.4)	1.0 0.47 (0.29-0.64)	1.0 0.49 (0.30-0.68)	<0.01
History of multiple HIV-testing1	No Yes	617 (42.5) 834 (57.5)	292 (47.3) 422 (50.6)	1.0 1.10 (0.98-1.22)	1.0 1.05 (0.93-1.17)	0.41
Spouse Characteristics (N=520)						
Currently pregnant	No Yes	446 (85.8) 74 (14.2)	231 (51.8) 30 (40.5)	1.0 0.78 (0.56-1.00)	1.0 0.82 (0.60-1.03)	0.12
Wife Reports ≥1 Child	No Yes	21 (4.0) 499 (96.0)	10 (47.6) 252 (50.4)	1.0 1.10 (0.58-1.62)	-	-
Wife previously HIV-tested	No Yes	24 (4.6) 496 (95.4)	17 (70.8) 245 (49.3)	1.0 0.67 (0.50-0.84)	1.0 0.66 (0.50-0.81)	0.01
Cluster-level Factors						
>50% of men employed	No Yes	581 (39.8) 878 (60.2)	326 (56.4) 388 (44.4)	1.0 0.88 (0.75-1.01)	1.0 0.92 (0.78-1.06)	0.30
>25% mention 3+ ways to prevent HIV infection	No Yes	715 (49.0) 744 (51.0)	307 (43.2) 407 (55.0)	1.0 1.16 (0.99-1.32)	1.0 1.12 (0.95-1.30)	0.13
HIV Prevalence	<10% >10%	1165 (79.8) 294 (20.2)	576 (49.7) 138 (47.4)	1.0 0.98 (0.81-1.16)	-	-
ART Available at Health Facility2	No Yes	680 (49.4) 697 (50.6)	338 (50.0) 328 (47.3)	1.0 0.97 (0.82-1.12)	-	-

Key: Number missing data: 1 8 men missing data on dates of first and last test and 56 missing HIV status data; N=1395; 2 82 missing data; 3 Adjusted for age, urban/rural residence and district; 4 Adjusted for variables higher in the conceptual framework (Figure 1); 5 For adjusted model & based on LRT, p-value in brackets is for assuming linear trend

Appendix 1. Characteristics of eligible men & Factors Associated with Participation (N=5797)

Characteristic	Detail	Distribution (n, col %)	Participants (n, row %)	Crude PR[a] (95% CI)
All Men	5797	-	2463 (42.5)	-
Age category	15-24	2303 (39.7)	934 (40.6)	1.0
	25-59	3494 (60.3)	1529 (43.8)	1.08 (1.02-1.15)
Head of Household	No	2590 (44.7)	921 (35.6)	1.0
	Yes	3207 (55.3)	1542 (48.1)	1.34 (1.25-1.43)
Present continuously previous 6mths	No	223 (3.8)	116 (52.0)	1.0
	Yes	5574 (96.2)	2347 (42.1)	0.80 (0.69-0.91)
SEP	Lowest	957 (16.5)	463 (43.4)	1.0
	Low	1038 (17.9)	471 (45.4)	0.96 (0.87-1.06)
	Middle	1206 (20.8)	536 (44.4)	0.93 (0.84-1.02)
	High	1275 (22.0)	517 (40.6)	0.84 (0.76-0.93)
	Highest	1321 (22.8)	476 (36.0)	0.74 (0.66-0.83)
Household Size	1-5	2736 (47.2)	1325 (48.4)	1.0
	6-10	2711 (46.8)	1029 (38.0)	0.78 (0.73-0.83)
	>10	350 (6.0)	109 (31.1)	0.64 (0.53-0.75)
Urban Cluster	No	4751 (82.0)	2042 (43.0)	1.0
	Yes	1046 (18.0)	421 (40.3)	0.94 (0.75-1.13)
District	Kafue	2106 (36.3)	886 (42.1)	1.0
	Chongwe	2810 (48.5)	1122 (39.9)	0.95 (0.81-1.10)
	Luangwa	881 (15.2)	455 (51.7)	1.23 (1.01-1.45)

Appendix 2. Distribution of eligible men by selection variables and association between participation and selection variables (N=5797)

Selection Variables	Description	Distribution	Participants	Crude PR	Adjusted PR1	p-value2
Time of Survey	Morning (630-1159)	2778 (47.9)	1140 (41.0)	1.0	1.0	
	Afternoon (12-1559)	2705 (46.7)	1204 (44.5)	1.09 (1.02-1.16)	1.08 (1.01-1.14)	0.02
	Late pm (16-1830)	314 (5.4)	119 (37.9)	0.92 (0.78-1.06)	0.94 (0.80-1.07)	
Day of Survey	Mon-Thurs	3825 (66.0)	1581 (41.3)	1.0	1.0	
	Friday	931 (16.1)	378 (40.6)	0.97 (0.89-1.06)	0.97 (0.88-1.05)	<0.01
	Sat-Sun	1041 (18.0)	504 (48.4)	1.15 (1.06-1.24)	1.14 (1.05-1.23)	
Season of Survey	Rainy (Dec-Apr)	1566 (27.0)	694 (44.3)	1.0	1.0	
	Cool, dry (May-Aug)	2646 (45.6)	1123 (42.5)	0.92 (0.78-1.05)	0.93 (0.81-1.05)	0.20
	Cool, hot (Sept-Nov)	1586 (27.4)	646 (40.7)	0.89 (0.72-1.05)	0.87 (0.73-1.01)	

Key: [1] Adjusted for household head, whether present all months in previous 6, household SEP and size, urban/rural residence and district; 2 For adjusted PR and based on LRT

Appendix 3. Distribution of characteristics of eligible men by selection variables (N=5797)

Characteristic	Detail	Monday-Thursday	Friday	Saturday-Sunday	p-value1
Household Head	No	1704 (65.8)	401 (15.5)	485 (18.7)	0.83
	Yes	2121 (66.1)	530 (16.5)	556 (17.3)	
Present continuously in previous 6mth	No	159 (71.3)	37 (16.6)	27 (12.1)	0.08
	Yes	3666 (65.8)	894 (16.0)	1014 (18.2)	
SEP Group	Lowest	603 (63.0)	157 (16.4)	197 (20.6)	<0.01
	Low	595 (57.3)	180 (17.3)	263 (25.3)	
	Middle	801 (66.4)	186 (15.4)	219 (18.2)	
	High	877 (68.8)	197 (15.5)	201 (15.8)	
	Highest	949 (71.8)	211 (16.0)	161 (12.2)	
Household Size	1-5	1817 (66.4)	438 (16.0)	481 (17.6)	0.49
	6-10	1758 (64.9)	449 (16.6)	504 (18.6)	
	>10	250 (71.4)	44 (12.6)	56 (16.0)	
Urban cluster	No	3104 (65.3)	750 (15.8)	897 (18.9)	0.43
	Yes	721 (68.9)	181 (17.3)	144 (13.8)	
District	Kafue	1507 (71.6)	287 (13.6)	312 (14.8)	0.09
	Chongwe	1792 (63.8)	464 (16.5)	554 (19.7)	
	Luangwa	526 (59.7)	180 (20.4)	175 (19.9)	
Characteristic	**Detail**	**Morning**	**Early pm**	**Late pm**	**p-value**
Household Head	No	1261 (48.7)	1183 (45.7)	146 (5.6)	0.28
	Yes	1517 (47.3)	1522 (47.5)	168 (5.2)	
Present continuously in previous 6mth	No	112 (50.2)	99 (44.4)	12 (5.4)	0.47
	Yes	266 (47.8)	2606 (46.8)	302 (5.4)	
SEP Group	Lowest	457 (47.8)	451 (47.1)	49 (5.1)	0.95
	Low	475 (45.7)	510 (49.1)	53 (5.1)	
	Middle	574 (47.6)	565 (46.9)	67 (5.6)	
	High	617 (48.4)	593 (46.5)	65 (5.1)	
	Highest	655 (50.0)	586 (44.4)	80 (6.1)	
Household Size	1-5	1288 (47.1)	1307 (47.8)	141 (5.2)	0.31
	6-10	1326 (48.9)	1247 (46.0)	138 (5.1)	
	>10	164 (46.9)	151 (43.14)	35 (10.0)	
Urban cluster	No	2279 (48.0)	2194 (46.2)	278 (5.9)	0.55
	Yes	499 (47.7)	511 (48.9)	36 (3.4)	
District	Kafue	993 (47.2)	980 (46.5)	133 (6.3)	0.42
	Chongwe	1352 (48.1)	1318 (46.9)	140 (5.0)	
	Luangwa	433 (49.2)	407 (46.2)	41 (4.7)	

Key: [1] p-value adjusted for clustering by study sites; Age category was correlated with household head, only household head was included in the Heckman model

8.3 Chapter Summary

More than half of ever-testers reported multiple lifetime HIV tests (14). As such, relative to never-testers, the factors associated with multiple HIV-testing were similar to those for ever-testing, including education, employment and a spouse who reported ever-testing (14). Although half the men reported multiple lifetime HIV-tests, few men reported more than two HIV-tests. Among ever-testers, employment and education remained associated with multiple HIV-testing. Few men living with HIV reported HIV-testing prior to the test in which they received their HIV-positive diagnosis. There was evidence that multiple-testing was lower in sites with more HIV-prevention related knowledge.

The offer of home-based HIV-testing to men with a history of ever-testing for HIV provided roughly half of ever-testers an opportunity to increase their lifetime frequency of HIV-testing (14). Some 3% of men who reported themselves HIV-negative or did not know their HIV-status tested HIV-positive at this test. Men whose spouse ever-tested were less likely to accept the offer of home-based HIV-testing as were household heads. Almost half the men with no history of HIV-testing did not accept the offering of home-based HIV-testing (Annex 4). Among men accepting the offer, 5% had an HIV-positive test result. In both surveys, over half the men (64%) testing HIV-positive at this test reported never-testing for HIV or that they were HIV-negative (Annex 4 (14)).

Chapter 9. Did the Scale-up of VMMC Services Contribute to Increasing Men's Population-levels of HIV-testing in Zambia, 2009-2013

9.1 Preamble to Paper IV: Did the Scale-up of VMMC Services Contribute to Increasing Men's Population-levels of HIV-testing in Zambia, 2009-2013

Although men's levels of HIV-testing increased between the two population-based surveys, some 40% of men never tested for HIV and few men reported more than two lifetime HIV-tests. With the aim of circumcising 80% of HIV negative males aged 15-49 years by 2015, the scale-up of VMMC services is likely to contribute to increasing men's levels of HIV-testing through the offer of PITC to men opting for circumcision. The scale-up of VMMC services may also have indirect effects through normalising HIV-testing, encouraging men not opting for circumcision to consider their HIV status and test for HIV, and facilitating more frequent HIV-testing among men who have undergone the process of VMMC.

Research Paper IV investigates this hypothesis. The scale-up VMMC services in the study area is described, including where services were delivered and promoted, and self-reported uptake of circumcision services since 2009. The HIV-testing behaviours of men who reported being circumcised are described and compared to uncircumcised men. Through an integrated analysis of routine monitoring data on the delivery of VMMC services and data from the two population-based surveys, the paper investigates whether the scale-up of VMMC services contributed to increasing population-levels of recent-testing.

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RESEARCH PAPER COVER SHEET

PLEASE NOTE THAT A COVER SHEET MUST BE COMPLETED FOR EACH RESEARCH PAPER INCLUDED IN A THESIS.

SECTION A – Student Details

Student	.Bernadette Hensen
Principal Supervisor	James Hargreaves
Thesis Title	Increasing men's uptake of HIV-testing in sub-Saharan Africa: a systematic review of interventions and analyses of population-based data from rural Zambia

If the Research Paper has previously been published please complete Section B, if not please move to Section C

SECTION B – Paper already published

Where was the work published?			
When was the work published?			
If the work was published prior to registration for your research degree, give a brief rationale for its inclusion			
Have you retained the copyright for the work?*	Choose an item.	Was the work subject to academic peer review?	Choose an item.

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SECTION C – Prepared for publication, but not yet published

Where is the work intended to be published?	AIDS Care
Please list the paper's authors in the intended authorship order:	Hensen B; Lewis JJ; Schaap A; Tembo, M; Weiss H; Chintu N; Hargreaves J; Ayles
Stage of publication	**Not yet submitted**

SECTION D – Multi-authored work

For multi-authored work, give full details of your role in the research included in the paper and in the preparation of the paper. (Attach a further sheet if necessary)	I conceived the idea for the manuscript with James Hargreaves. I planned, with support from James Hargreaves and James Lewis, and conducted all analyses. I interpreted the findings and wrote the first draft of the manuscript.

Student Signature: ______________________ **Date:** 15/7/15

Supervisor Signature: ______________________ **Date:** 14/7/15

9.2 Research Paper IV:

Did the scale-up of voluntary medical male circumcision services contribute to increasing men's population-levels of HIV-testing in Zambia, 2009-2013

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Abstract

Introduction: Since 2009, voluntary medical male circumcision (VMMC) services have been scaled-up across Zambia. Men opting for circumcision are offered provider-initiated HIV-testing and counselling (PITC) prior to being circumcised. Through the offer of PITC, VMMC services may contribute to increasing men's ever-testing and normalising knowing ones HIV status amongst men. The scale-up of VMMC services has the potential to increase population-levels of HIV-testing amongst all men, including men not opting for circumcision.

Methods: We conducted an integrated analyses of programmatic data, systematic observations and population-based surveys, to describe the scale-up of VMMC services, including delivery, promotion and uptake, in three rural Zambian districts. Using a 2013 survey, we describe the HIV-testing behaviours of men self-reporting circumcision between 2009 and 2013. We used cluster-level summaries to investigate whether VMMC contributed to increasing levels of recent HIV-testing.

Results: VMMC services were delivered in 62% (n=26) of the study sites. Posters were observed in 58% (n=15) of the study sites where VMMC services were delivered. No other promotional activities were observed. Some 6% (n=138) of men reported being circumcised between 2009 and 2013 among whom 86% (n=118) ever-tested for HIV. Among circumcised men, 32% reported one lifetime HIV-test. The cluster-level mean of recent HIV-testing was 33% in sites where VMMC services were scaled-up compared to 30% in sites where services were not. There was little evidence that recent HIV-testing was higher in sites where VMMC services had been scaled-up.

Conclusion: The scale-up of VMMC services provides men with an opportunity to test for HIV, however, the contribution to increasing population-levels of HIV-testing is low in this setting as few men opted for circumcision and a high proportion had already tested for HIV. There was little evidence that the scale-up of services increased HIV-testing among all men.

Introduction

In 2007, the World Health Organization recommended that 14 priority countries, including Zambia, implement voluntary medical male circumcision (VMMC) services as part of a comprehensive HIV-prevention strategy (1-5). The recommendation was based on evidence from three trials that male circumcision could reduce by two-thirds a man's risk of HIV-infection (1-3). VMMC is a community-based, combination HIV-prevention intervention, with provider-initiated HIV-testing and risk reduction counselling (PITC) and condoms offered to men opting to be circumcised (4).

Acceptance of PITC in VMMC clinics is high (6); the scale-up of VMMC services is likely to have a direct effect on men's population-levels of ever-testing for HIV. The scale-up of VMMC services may also have indirect effects on men's HIV-testing. If service availability and promotion become widespread, more men may opt for VMMC and learn their HIV-status through PITC. Circumcised men may discuss the process of undergoing VMMC with friends and family, and more men may be aware of the availability of PITC in VMMC clinics. As such, the scale-up of VMMC services could contribute to "normalising" HIV-testing among men, encouraging men not opting for circumcision to test for HIV and men who have been circumcised to increase their lifetime frequency of HIV-testing (7, 8).

In 2009, Zambia adopted VMMC services as a component of the national HIV prevention strategy (9). Zambia aims to circumcise 80% of HIV-negative men aged 15-49 years by 2015. By 2013, an estimated 17% of target males were circumcised (10). Using programmatic data, systematic observations and population-based surveys, we explored the HIV-testing behaviours of men who opted for circumcision. We also explored whether, where VMMC services had been scaled-up, there was evidence that VMMC contributed to increasing population-levels of HIV-testing.

Methods

This study was conducted in 42 sites, defined as a health facility and its catchment area, in three districts in Lusaka Province, Zambia. Data came from four sources: programmatic data from Society for Family Health (SFH), systematic observations, and two population based surveys.

Programmatic data was routine data on where in the study area VMMC services had been delivered and the number of circumcisions performed by SFH from January 2009 to December 2013. Data were available for all males and males aged 15 years or older. Data on VMMC promotion were collected through systematic observations conducted once in each study site. Systematic observation collects data in a replicable manner on physical conditions within a setting (11). A protocol and observation schedule were used to collect data on the number of VMMC-related posters and other promotional activities, including drama and community announcements, observed at the health facility. The protocol was based on a protocol used in the observation of alcohol-related advertisements (12). After completion of data collection at the health facility, observations were conducted within a 1.5km radius and in two randomly selected high density areas within a 3.8km radius of the health facility in each study site. High density areas were defined as landmarks, including schools, markets, or bus stations, where VMMC services were likely to be promoted. Observations were conducted from July to August 2013.

The population-based surveys were conducted for an unrelated cluster-randomised trial (CRT), namely the Better Health Outcomes through Mentoring and Assessment (BHOMA) trial. Details of the trial are published elsewhere (13-15). Briefly, BHOMA is a health system strengthening intervention that aims to reduce age-adjusted all-cause and under-5 mortality (14). HIV-testing and circumcision were not outcomes of BHOMA. Data used from the BHOMA evaluation were individual surveys completed by men residing in households within randomly selected squares in a 3.8km radius of the health facility. Details of cluster demarcation and household selection are detailed elsewhere (13, 14, 16). Household members aged 15-59 years were eligible for the individual questionnaire, which included questions on demographics and health, including HIV-testing history and male circumcision status (2013 survey only). Individuals were offered rapid HIV-testing (Determine™ HIV-1/2) upon questionnaire completion (13, 16). Data were collected from May 2011-February 2012 (2011/12 survey) and February-November 2013 (2013 survey).

Statistical Analysis

Our analyses were conducted in three stages. First, we described the scale-up of VMMC services, including the number of VMMC services delivered and the number of sites where SFH delivered services, and the estimated proportion of males aged 15 years or older circumcised in these sites. We estimated the proportion of men circumcised using data on the catchment population of each health facility and the proportion of the district that were males aged 15 years or older (17, 18). We described the promotion of VMMC services using systematic observation data. Using the 2013 survey, we described knowledge of VMMC service availability and of the partial protective effect of circumcision among all men (N=2376). We described the proportion of men self-reporting being circumcised between 2009 and 2013, excluding men circumcised aged <15 years or prior to 2009, and men diagnosed HIV-positive >5 years before the survey (N=2223). We described and compared the characteristics of men circumcised between 2009 and 2013 and uncircumcised men.

In the second stage, we described and compared ever-testing and receiving the result of an HIV-test among men circumcised between 2009 and 2013 to uncircumcised men. We estimated the association between circumcision and ever-testing, adjusting for potential confounders, including age, education, occupation, religion, marital status and household socioeconomic position (SEP). We described the proportion of men reporting one lifetime HIV-test by circumcision status. Among circumcised men, we estimated the proportion ever-testing for HIV before and retesting for HIV after being circumcised. Finally, we described the proportion of men reporting a recent HIV-test, defined as testing within the year preceding the 2013 survey, by circumcision status and estimated the association between a recent-circumcision and recent-testing. We removed from this analyses men who reported being diagnosed HIV-positive >1 year preceding the survey (N=2155).

In the third stage, we explored whether, in sites where VMMC services had been scaled-up, more men had recently tested for HIV than in sites where services had not been scaled-up. We defined sites as where services had been scaled-up if SFH reported delivering any VMMC services or the site included a hospital. First, we compared the cluster mean of the proportion of men circumcised between 2009 and 2013, recently circumcised, the mean knowledge of VMMC service availability and of the partially protective effect of circumcision in sites where VMMC services had been scaled-up to sites where they had not. We then described and compared the mean proportion of recent-testing in the 2013 and 2011/12 surveys by these two groups. We estimated cluster-level summaries of recent-testing among all men, regardless of circumcision status, excluding men diagnosed HIV-positive >1 year prior to the surveys. We estimated the crude prevalence difference (PD) in recent-testing in the 2013 survey and associated 95% confidence intervals (95%CI). We adjusted for *a priori* considered confounders, namely district, urban/rural residence, population size and HIV prevalence (estimated using results from rapid HIV-testing offered to survey participants)(12). We explored whether there was evidence for imbalances in individual-level factors associated with recent-testing across the two groups using standard regression models and robust standard errors to adjust for clustering (12). Where there was evidence for imbalance (p<0.10) we controlled for the variable in adjusted analyses.

To adjust for covariates we used a two-stage process used in the analysis of CRTs (15). Briefly, we ran standard logistic regression models on the outcome without including a covariate for study group or clustering, to obtain expected outcomes (15). At cluster-level, we obtained residuals by estimating the difference in the observed and expected outcomes for each site. We estimated an adjusted PD (adjPD) and associated 95%CI. We obtained p-values using the t-test or rank sum test depending on the distribution of the residuals. We explored whether there was evidence that the effect of VMMC services was modified by BHOMA. To estimate how much of the effect was due to men opting for circumcision, we adjusted for self-reported recent circumcision. We further adjusted for accurate knowledge of VMMC service availability and of the partial protective effect of circumcision to estimate any indirect effect.

As services were scaled-up rapidly in 2012, we explored the sensitivity of the results to defining sites as where services were scaled-up if services were delivered in 2012 or later. We also explored the sensitivity to using self-reported circumcision to define sites as where services were scaled-up.

Ethics Statement

The University of Zambia Bioethics Committee, the London School of Hygiene and Tropical Medicine (LSHTM) Ethics Committee and the institutional review boards at the University of Alabama at Birmingham (Birmingham, AL, USA) and the University of North Carolina (Chapel Hill, NC, USA) approved the BHOMA trial (13). Individuals were informed of the study objectives and asked for written informed consent. The systematic observations were approved by the University of Zambia Bioethics Committee, the LSHTM Ethics Committee, and the Zambian Ministries of Health and of Community Development, Mother and Child Health.

Results

The Delivery of VMMC Services, 2009-2013

By 2013, SFH had delivered VMMC services to 5307 males in 60% (n=25) of the study sites. An estimated 4% (median: 3% IQR=0.7%-5.2%) of males aged 15 years or older were circumcised in these sites (Figure 1). VMMC services were available at a hospital in one site. Overall, VMMC services were scaled-up in 62% (n=26) of study sites. Some 23% (n=6) of the sites were peri-urban. Services were delivered in 71% (n=10) of sites in Kafue, 57% (n=12) in Chongwe and 57% (n=4) in Luangwa district.

VMMC-related posters were observed in 50% (n=21) of all study sites. All 21 sites had posters at the health facility. Posters were observed in the 1.5km radius in four sites. None were observed within the 3.8km radius. Most sites (n=13; 62%) had one VMMC-related poster. Posters were observed in over half (n=15/21; 58%) the sites where VMMC services were scaled-up. No other promotional activities were observed.

In the 2013 survey, 82% (n=1930) of men had heard of VMMC; of these men, 64% (n=1240; 52% of all men) agreed that circumcision was partially protective against HIV-infection. Some 40% (n=957) of men reported that VMMC was available at the health facility or through mobile/outreach services in their community; 28% (n=657) did not know whether VMMC was available. Among these men, sources of information on VMMC availability included: a healthcare worker at the local facility (n=324; 34%), community announcements (n=249; 26%); posters in the community and/or the health facility (n=227; 24%); and friends/family members (n=188; 20%).

Some 6% (n=138/2223) of men reported being circumcised since 2009, 54% (n=74) were circumcised recently. By study site, the estimated proportion of men circumcised by SFH was correlated with self-reported circumcision (r=0.38; p=0.01; Figure 2). Circumcised men were more likely to be younger, single, report complete secondary/higher education and be of higher SEP, than uncircumcised men (Table 1).

HIV-testing behaviours of men opting for VMMC

Some 86% (n=118) of circumcised men reported ever-testing for HIV compared to 59% (n=1222) of uncircumcised men (adjPR=1.46; 95%CI: 1.35-1.57; p<0.01). Among circumcised men, 80% (n=111) reported being offered PITC prior to being circumcised and 96% (n=106) accepted PITC. Overall, 77% (n=106/138) of circumcised men were offered and accepted PITC.

Some 32% (n=38) of circumcised men with a history of HIV-testing reported one lifetime HIV-test compared to 43% (n=513) of uncircumcised men (p=0.02). An estimated 45% (n=53/118) of circumcised men had HIV-tested before the year of their circumcision. Overall, 55% (n=65) of circumcised men first HIV-tested by undergoing circumcision. An estimated 52% (n=61) of circumcised men with a history of HIV-testing retested after being circumcised. A recent test was reported by 66% (n=91) of circumcised men compared with 28% (n=565) of uncircumcised men (adjPR=2.40 95%CI: 2.05-2.76; p<0.01).

Population-level effect of VMMC

In 2013, the cluster-level mean knowledge of the partial protective effect of circumcision was 58% (range: 33.3 to 81.3) in sites where services had been scaled-up compared with 52% (range: 25.4 to 83.1) in sites where services had not been scaled-up (Table 3). Accurate knowledge of service availability was 50% (range: 11.3 to 82.6) compared to 56% (range: 24.2 to 92.5), respectively. The cluster-level mean of circumcision was 8% (range: 0 to 17.4) compared to 5% (range: 0 to 21.1) and recent circumcision was 5% (range: 0 to 10.0) compared to 2% (range: 0 to 10.0), respectively.

The cluster-level mean of recent HIV-testing was 33% (95%CI: 29.4 to 36.9) in sites where services were scaled-up compared to 30% (95%CI: 23.0 to 36.2) where services were not scaled-up (PD=3.5%; 95%CI: -3.8 to 10.8). The difference was similar after adjustment for cluster-level confounders, district and imbalances in education across the two groups (adjPD=3.6% 95%CI: -3.2 to 10.3; Table 2 & 3). There was little evidence for interaction with the BHOMA intervention (p=0.13). Adjusting for self-reported recent circumcision, the PD was attenuated (adjPD=2.4% 95%CI: -4.2 to 9.0). Results were similar in the sensitivity analyses (Appendix 1 & 2).

Discussion

We investigated whether the scale-up of VMMC services might have contributed to increasing men's population levels of HIV-testing in three rural Zambian districts. Although most men undergoing VMMC are offered PITC, with few men opting for circumcision and an estimated 45% of circumcised men HIV-tested prior to the date of their circumcision, we conclude that the contribution to ever-testing is low in this rural setting. Furthermore, we found little evidence that population-levels of recent HIV-testing were higher in sites where VMMC services had been delivered, suggesting that the scale-up of VMMC services did not increase HIV-testing among all men.

Our observational study had limitations, including the use of secondary data from an unrelated CRT. HIV-testing data were self-reported, retrospective and were only available on year of first and most recent HIV-test. Men may have over-reported HIV-testing and misreported dates of HIV-tests and age of circumcision. If men over-reported their frequency of HIV-testing or misreported the date of their first HIV-test, our study may underestimate the proportion of circumcised men having their first HIV-test through the VMMC process. Furthermore, we did not ask circumcised men whether they HIV-tested again after being circumcised but inferred this from dates of HIV-testing and age of circumcision. Our estimates of the proportion of men testing before and after their circumcision need to be interpreted with caution. It is unlikely, however, that misreporting a recent HIV-test would be differential by study group. We therefore do not expect misreporting to affect our overall findings of the contribution of VMMC scale-up to HIV-testing.

The systematic observations were cross-sectional, the absence of promotion on the day of observation does not preclude previous promotional activities. The observations did not collect data on promotion through radio or interpersonal communication through which services were also promoted. Data on men's exposure to promotional activities were not available.

At the time of the study, VMMC services were being scaled-up by various providers with mass media promotion at national-level, particularly around "Male Circumcision Month" in August (19). Men residing in sites defined as "control" sites may have been exposed to VMMC service promotion. Furthermore, the men circumcised in sites where services were delivered may not have resided in the catchment area. In a six-week VMMC campaign in Tanzania, 50% of the men accessing VMMC in five health facilities resided >15km from the facility catchment areas (20). This contamination would bias our effect to the null. Considering the low estimated proportion of men circumcised and little widespread promotion, we consider it unlikely that VMMC services could have had an indirect effect regardless of any potential for contamination.

Although we would have expected to detect an overall effect through the offer of PITC to circumcised men, particularly as the majority of men were recently circumcised, considering the small difference in recent-testing across the two groups our study was likely under powered to detect this effect. Finally, nested within a CRT of a health systems strengthening intervention, the generalisability of the findings may be limited as, although not an outcome of the intervention, BHOMA may have increased HIV-testing through improved delivery of PITC services.

Despite limitations, this is the first attempt to use programmatic data, systematic observations and population-based survey data to describe the scale-up of VMMC services and explore evidence for a contribution to population-levels of HIV-testing through direct and indirect pathways. Although we found little evidence in support of a direct effect, one-third of circumcised men reported one lifetime HIV-test. In Lesotho (2012), 65% of males aged 15-49 who had been HIV-tested in a hospital accessed HIV-testing services through VMMC clinics (21). Some 16% (n=72) of men testing HIV-positive tested through VMMC services (21). In South Africa and Zimbabwe, VMMC services provided universal access to HIV-testing among men opting for circumcision (6, 22). VMMC clinics are therefore an additional setting through which to provide men with access HIV-testing services. However, with 20% of men in this study not offered PITC, strengthened implementation of PITC in VMMC clinics is required.

With only 6% of men reached with VMMC services, there is a need to increase demand for services and improve service delivery. With few promotional activities identified in the study sites, greater emphasis on promoting services through mediums other than posters will likely be required to improve reach and provide more opportunity to offer men PITC prior to circumcision. Furthermore, in this rural setting, services were predominantly facility-based. Providing services through mobile clinics may also facilitate increasing reach of VMMC services and providing more men with HTC and complimentary services through VMMC clinics.

We found little evidence that the scale-up of VMMC services encouraged circumcised men to increase their lifetime frequency of HIV-testing. Similar to other studies, almost half the men accessing VMMC in this study were 15-20 years old at the time of circumcision (23). VMMC likely removes barriers younger men face in accessing HIV-testing (21), including lack of adolescent-friendly services (13, 22). By providing PITC services to younger men, VMMC may "normalise" HIV-testing among these men, analogous to the effect of PITC in ANC among younger females (24). In South Africa, levels of repeat HIV-testing were higher among younger non-pregnant females with children, suggesting that PITC in ANC encourages younger women to see HIV-testing as a routine component of healthcare (24). The risk-reduction counselling offered to men prior to circumcision may encourage men at continued risk of HIV-infection to retest for HIV annually. Exploring an effect on frequency of HIV-testing warrants additional research (22).

An indirect effect among men not opting for circumcision may have been an unrealistic expectation for a single visit, one-off intervention. Alternatively, it may have been an unrealistic expectation during the "catch-up" phase, when VMMC was a novel intervention, there was little evidence of community-level service promotion, and service uptake was relatively low (9, 23, 25). This may be particularly true in this rural setting, where there was little evidence of widespread promotion and services were largely delivered through facilities. Yet, similar to studies in Uganda and South, knowledge of VMMC was high, half the men were aware of the prevention benefits of circumcision and reported that services were available (26, 27). It remains plausible that VMMC services have the potential to contribute to increasing levels of HIV-testing among all men. Such an effect may require more time, for more men to opt for circumcision and increased VMMC-related conversations. In Lusaka, circumcised men reported friends as an important source of VMMC-related information (28). In Uganda (2004-2006), men viewed circumcision as an opportunity to access HTC services (29). As "male-friendly" settings, VMMC clinics may be a more acceptable location for men to access HIV-testing and counselling (HTC) services (30, 31). Failure to harness the potential of VMMC services to "normalise" HIV-testing and provide more men with access to HTC services seems a missed opportunity (22). To facilitate uptake of HTC services in settings where VMMC services are offered, resources should be directed towards promoting the availability of HTC within these settings and that all men are able to access these services regardless of their intention to be circumcised (13, 32). In addition, HIV self-testing kits could be made available through VMMC clinics, as self-testing for HIV may prove more acceptable to men (16, 33, 34). Research to explore the acceptability, feasibility and effectiveness of offering self HIV-test kits through VMMC clinics, particularly in an urban Zambian setting, is warranted (35).

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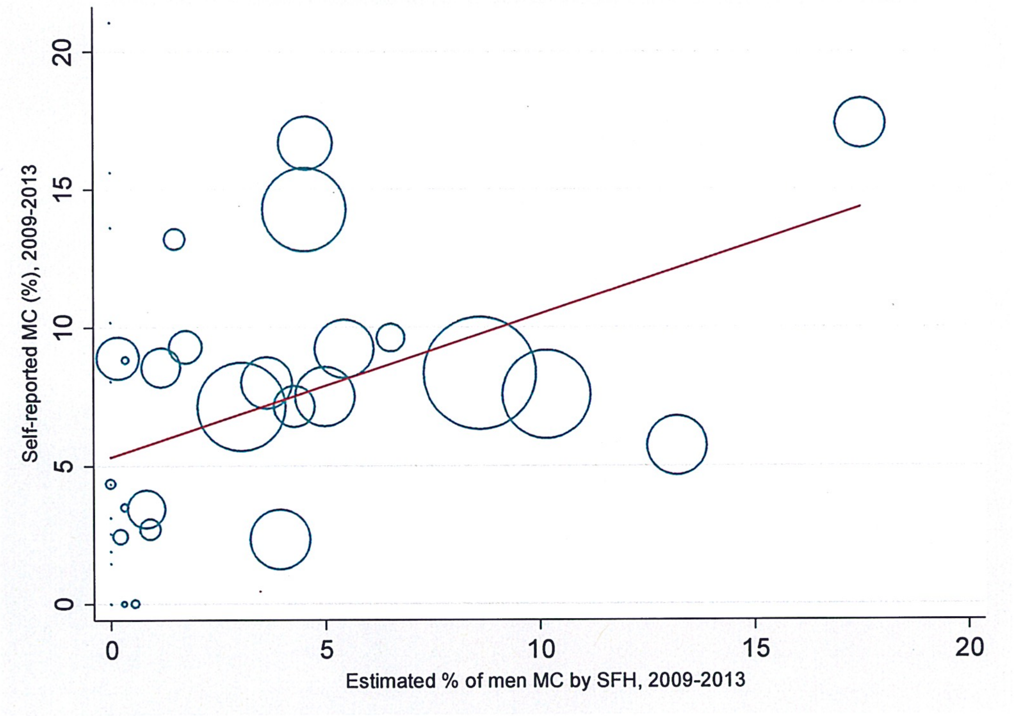
Figure 1. The Delivery, Promotion and Uptake of VMMC Services in the 42 Study Sites and the Population-Levels of Ever- and Recent-Testing for HIV

Site	Estimated %MC (SFH)	# posters	% Self-report MC	Ever HTC	% Self-report recent MC	Recent HTC
1	17.5	7	17.4	73.9	9.5	37.0
2	13.2	3	5.7	70.7	2.9	40.0
3	10.3	2	7.6	53.6	6.2	29.0
4	5.0	1	7.5	61.9	0.0	28.6
5	8.6	0	8.3	54.7	4.3	26.4
6	5.5	1	9.2	46.6	1.7	16.4
7	3.1	2	7.1	62.5	7.1	31.3
8	6.5	1	9.6	56.6	9.6	37.7
9	4.5	0	16.7	87.1	7.4	51.6
10	3.9	0	2.3	80.0	2.3	40.0
11	4.3	1	7.1	48.7	5.8	27.6
12	4.5	1	14.3	48.9	10.0	28.9
13	1.2	1	8.6	60.3	5.9	39.7
14	0.2	1	8.9	52.1	8.9	33.3
15	3.6	0	8.0	56.6	4.2	30.1
16	1.8	0	9.3	74.5	9.3	40.4
17	0.9	0	2.7	46.5	2.7	18.6
18	0.8	1	3.4	57.1	0.0	31.7
19	1.5	0	13.2	56.4	9.8	29.1
20	0.6	0	0	60.3	0.0	31.0
21	0.2	4	2.4	66.7	2.4	52.4
22	0.4	0	8.8	39.5	3.1	28.9
23	0.3	2	3.5	57.6	1.8	18.6
24	0.2	0	4.3	72.3	4.3	38.3
25	0.3	0	0	81.8	0.0	48.5
26	0	1	13.6	60.9	5.0	26.1
Mean[1]	**4.0**	**29.0**	**7.7**	**61.1**	**4.8**	**33.1**
27	0	1	2.6	62.5	0	17.5
28	0	0	0	63.2	0	44.7
29	0	0	0	66.7	0	18.2
30	0	1	10.2	52.9	6.4	19.6
31	0	2	1.9	53.7	0	20.4
32	0	0	15.6	60.6	6.9	45.5
33	0	0	0	60.8	0	24.1
34	0	0	0	78.8	0	51.9
35	0	1	8.1	63.5	5.0	38.1
36	0	0	4.3	54.3	0	38.6
37	0	0	5.3	63.9	0	37.3
38	0	0	3.1	61.2	1.6	28.4
39	0	0	0	65.9	0	39.0
40	0	0	0	54.7	0	17.0
41	0	1	1.5	42.0	0	11.6
42	0	3	21.1	55.9	10	22.0
Mean[1]	**-**	**9**	**4.6**	**60.0**	**1.9**	**29.6**

Key: SFH - Society of Family Health; HTC - HIV testing and counselling; MC - Male circumcision; [1] Sum for posters; Sites in light grey are where VMMC services were delievered by SFH (2009-2013) or a hospital

Figure 2. Scatter plot of the correlation between self-reported circumcision between 2009 and 2013, and the estimated % of men circumcised by SFH (2009-2013)



Footnote 1 MC – circumcised; SFH – Society for Family Health; Size of circles proportional to number of VMMC services delivered to all males

Table 1. Distribution of characteristics among all men and by circumcised and uncircumcised men (N=2223)[1]

	Details	All men (n, col %)	Men not circumcised (n, col %)	Men MC 2009-2013 (n, col %)	p-value[2]
		2223	2085 (93.6)	138 (6.4)	-
Age	15-19	471 (21.2)	435 (20.9)	36 (26.1)	<0.01
	20-29	717 (32.3)	646 (31.0)	71 (51.5)	
	30-39	496 (22.3)	472 (22.6)	24 (17.4)	
	≥40	539 (24.3)	532 (25.5)	7 (5.1)	
Education	No Education/Primary	970 (43.6)	951 (45.6)	19 (13.8)	<0.01
	Some secondary	835 (37.6)	775 (37.2)	60 (43.5)	
	Complete secondary /higher	418 (18.8)	359 (17.2)	59 (42.8)	
Occupation	None	1036 (46.6)	960 (46.0)	76 (55.1)	<0.01
	Agricultural (others land)	496 (22.3)	477 (22.8)	19 (13.8)	
	Agricultural (own land)	431 (19.4)	413 (19.8)	18 (13.0)	
	Professional/services	260 (11.7)	235 (11.3)	25 (18.1)	
Religion	Protestant	849 (38.2)	798 (38.3)	51 (37.0)	<0.01
	Catholic	577 (26.0)	531 (25.5)	46 (33.3)	
	SDA	330 (14.8)	306 (14.7)	24 (17.4)	
	Other	376 (16.9)	362 (17.4)	14 (10.1)	
	None	91 (4.1)	88 (4.2)	3 (2.2)	
Marital Status	Single	951 (42.8)	857 (41.1)	94 (68.1)	<0.01
	Married/cohabiting	1178 (53.0)	1138 (54.6)	40 (29.0)	
	Ever married	94 (4.2)	90 (4.3)	4 (2.9)	
Household SEP	Lowest	435 (19.6)	412 (19.8)	23 (16.7)	<0.01
	Low	423 (19.0)	414 (19.9)	9 (6.5)	
	Middle	495 (22.3)	464 (22.3)	31 (22.5)	
	High	466 (21.0)	435 (20.9)	31 (22.5)	
	Highest	404 (18.2)	360 (17.3)	44 (31.9)	

Key: MC – circumcised; [1] Men circumcised as children or pre-2009, or missing data on circumcision status removed from the analyses n=131 and men knowing their HIV+ status >5yrs prior to the survey removed from the analyses n=22; [2] From likelihood ratio test and random effects logistics regression adjusted for age, urban/rural residence, district, and clustering

Table 2. Distribution and comparison of characteristics associated with recent-testing among men by study sites where circumcisions were not and were scaled-up (N=2281)[1]

		VMMC not scaled-up	VMMC scaled-up	p-value[2]
Age	Median (IQR)	29 (21-40)	27 (20-38)	0.10
Marital Status	Single	350 (40.0)	635 (45.5)	
	Married/Cohabiting	495 (55.9)	702 (50.3)	0.32
	Separated/widowed/divorced	40 (4.5)	59 (4.2)	
Religion	Protestant	356 (40.2)	517 (37.0)	
	Catholic	231 (26.1)	363 (26.0)	
	SDA	97 (11.0)	245 (17.6)	0.47
	Other	153 (17.3)	225 (16.1)	
	None	48 (5.4)	46 (3.3)	
Education	None/Primary	421 (47.8)	544 (39.0)	
	Secondary	323 (36.5)	535 (38.3)	0.08
	Complete secondary/higher	141 (15.9)	317 (22.7)	
Occupation	None	412 (46.6)	651 (46.6)	
	Agriculture (others land)	184 (20.8)	320 (22.9)	0.64
	Agriculture (own land)	197 (22.3)	237 (17.0)	
	Professional/services	92 (10.4)	188 (13.5)	
History of TB Treatment	No	864(97.6)	1352 (96.9)	0.29
	Yes	21 (2.4)	44 (3.1)	
Household SEP	Lowest	212 (24.0)	225 (16.1)	
	Low	174 (19.7)	254 (18.2)	
	Middle	167 (18.9)	325 (23.3)	0.31
	High	187 (21.1)	294 (21.1)	
	Highest	145 (16.4)	298 (21.4)	

Key: [1] Excludes men who reported themselves as living with HIV >1yr preceding the survey (n=72) and men with missing data on year of last HIV-test (n=23); [2] From wald test adjusted for clustering by study site

Table 3. Distribution of study sites and recent-HTC by study sites where VMMC services were delivered and by where none were delivered and the effect of VMMC services on population-levels of recent HTC

	No VMMC Services Delivered	VMMC Services Delivered	
Number of Clusters	16 (38.1)	26 (61.9)	
Recent HTC 2013 (%; range)	29.6 (11.6-51.9)	33.1 (16.4-52.4)	
Recent HTC 2011/12 (%; range)	25.8 (14.6-43.4)	25.9 (11.4-40.9)	
Recent MC (%; range)	1.9 (0-10.0)	4.8 (0-10.0)	
Knows of relationship between MC and HIV (%; range)	52.2 (25.4-83.1)	58.4 (33.3-81.3)	
Accurate knowledge of VMMC availability (%; range)	56.4 (24.2-92.5)	49.8 (11.3-82.6)	
Overall Effect		**Prevalence difference**	**p-value[1]**
Model 1: Crude prevalence difference (%; 95%CI)	-	3.5 (-3.8 to 10.8)	0.30
Model 2: Model 1 + adjustment for age, cluster-level confounders, urban residence and district		3.8 (-2.8 to 10.4)	0.25
Model 3: Model 2 + adjustment for education		3.6 (-3.2 to 10.3)	0.29
Direct and Indirect Effects			**p-value[1]**
Model 4: Model 3 + meditation by recent male circumcision	-	2.4 (-4.2 to 9.0)	0.47
Model 5: Model 4 + mediation by knowledge of services availability and HIV-prevention benefits of male circumcision		2.1 (-4.5 to 8.7)	0.53

Key: [1] p-value based on t-test, where the distribution was non-normal the rank sum test was used

Appendix 1. The distribution of study sites by where services were delivered in 2012 and the estimated contribution of VMMC services to recent HIV-testing by using Delivery since 2012 to define study sites

	VMMC Services not Delivered	VMMC Services Delivered	
Number of Clusters (%)	20 (47.6)	22 (52.4)	
Recent HTC 2013 survey (%; range)	29.5 (11.6-51.9)	33.8 (16.4-52.4)	
Recent HTC 2011/12 survey (%; range)	26.9 (14.6-43.4)	24.7 (11.4-40.4)	
Recent circumcision (%; range)	2.4 (0-9.4)	4.3 (0-8.9)	
Knowledge of protective effect of male circumcision (%; range)	52.6 (25.3-83.1)	59.2 (33.3-81.3)	
Accurate knowledge of VMMC Service Availability (%; range)	50.8 (6.1-81.1)	53.6 (20.5-82.6)	
Overall Effect		**Prevalence difference**	**p-value[1]**
Model 1: Crude prevalence difference (%; 95%CI)	-	4.3 (-2.3 to 10.9)	0.19
Model 2: Model 1 + adjustment for age, cluster-level confounders, urban residence and district		4.8 (-1.6 to 11.2)	0.13
Model 3: Model 2 + adjustment for imbalances in religion and education		4.2 (-2.3 to 10.6)	0.19
Direct and Indirect Effects		**Prevalence difference**	**p-value[1]**
Model 4: Model 3 + adjustment for recent circumcision	-	3.0 (-3.3 to 9.4)	0.34
Model 5: Model 4 + adjustment for knowledge of services availability and HIV-prevention benefits of circumcision	-	2.9 (-3.5 to 9.3)	0.37

Key: [1] p-value based on t-test, where the distribution was non-normal the rank sum test was used

Appendix 2. The distribution of study sites by self-reported circumcision between 2009 and 2013 and the effect of where VMMC services were reported on population-levels of recent HIV-testing

	No Circumcisions Reported	**Circumcisions Reported**	
Number of Clusters (%)	8 (19.0)	34 (81.0)	
Recent HTC 2013 (%; range)	34.3 (17.0-51.9)	31.2 (11.6-52.4)	
Recent HTC 2011/12 (%; range)	24.2 (14.6-43.4)	26.2 (11.4-40.9)	
Self-report recent MC (%, 95%CI)	0	4.1 (3.0-5.2)	
Knowledge of protective effect of male circumcision (%; 95%CI)	45.9 (27.5-61.3)	58.4 (25.4-83.1)	
Accurate knowledge of VMMC Service Availability (%; range)	61.6 (29.3-92.5)	50.1 (11.3-82.6)	
Overall Effect		**Prevalence difference**	**p-value**
Model 1: Crude prevalence difference (%; 95%CI)	-	-3.1 (-11.5 to 5.3)	0.46
Model 2: Model 1 + adjustment for age, cluster-level confounders, urban residence and district	-	-2.9 (-11.1 to 5.2)	0.47
Model 3: Model 2 + adjustment for TB history, education, marital status & SEP	-	-2.8 (-11.1 to 5.6)	0.51
Direct and Indirect Effect		**Prevalence difference**	**p-value**
Model 4: Model 3 + adjustment for recent MC	-	-4.3 (-12.6 to 3.9)	0.29
Model 5: Model 4 + adjustment for knowledge of services availability and HIV-prevention benefits of MC	-	-4.4 (-12.6 to 3.8)	0.28

Key: [1] p-value based on t-test, where the distribution was non-normal the rank sum test was used

9.3 Chapter Summary

Male circumcision was associated with ever- and recently-testing for HIV. A high proportion of men opting for circumcision accepted the offer of PITC prior to being circumcised yet some 20% reported not being offered PITC. Almost half the men accepting PITC were estimated to have tested for HIV before accessing VMMC services. There was little evidence that the scale-up of VMMC services contributed to increasing population-levels of HIV-testing. A lack of an indirect effect among men not opting for circumcision is likely attributable, in part, to the lower than expected promotion and uptake of VMMC services.

Although VMMC service scale-up gained momentum in 2012, with the release of the national operational plan. and communications and advocacy strategy (116, 119), there was little evidence that HIV-testing was higher in sites where VMMC services has been scaled-up since 2012. At the time of the study, VMMC services were being delivered by various service providers, including mission and district hospitals, and promoted at national-level. Using self-reported circumcision as a proxy for exposure to VMMC services scale-up similarly showed little evidence in support of the hypothesis.

Section 4: Discussion and Conclusion

Chapter 10: Discussion

Across sub-Saharan Africa, men's levels of HIV-testing remain low relative to women's and to revised UNAIDS 90-90-90 targets (1, 109, 147). Fewer men living with HIV are aware of their HIV-positive status and men initiate ART at later stages of HIV-infection (148). In 2011, WHO estimated that 44% of individuals eligible for ART in Africa were male (1). Yet, males comprised 36% of individuals on ART (1). A concerted effort is required to increase men's levels of HIV-testing across the region to facilitate improved access to HIV-treatment and care, provide risk reduction counselling to men at continued risk of HIV-infection and realise the potential of proven prevention interventions (1, 50, 147). Evidence is required to support this effort.

Through four research papers and linking chapters, this thesis aimed to provide such evidence. Through a systematic review, I identified the strategies effective at increasing men's levels of HIV-testing. With a focus on Zambia, I investigated men's levels of and the factors associated with HIV-testing in an era of expanded availability and promotion of HTC (26). In this chapter, I summarise my findings, highlight the strengths and limitations of the research methods and discuss the findings in relation to the literature. Finally, I synthesise the findings to recommend strategies and highlight research priorities to increase men's HIV-testing in Zambia.

10.1 Summary of Findings

Research Paper I identified 16 trials effective at increasing men's levels of HIV-testing (19). Four strategies specifically targeted men through their pregnant partners (19, 149-152). Although effective, few men attended ANC (19, 149, 150). Strategies that included community sensitisation or offered HTC in non-facility settings showed the greatest effect on HIV-testing uptake (19, 149, 152). Eight community-based trials were identified (19). Mobile HTC with community mobilisation and post-test support reached a high proportion and number of men (19, 153). HIV-prevalence was higher in standard VCT sites, yet the number of HIV-positive individuals was 5-fold higher in mobile HTC communities (153). Door-to-door home-based HTC reached a high proportion of first-time testers, and provided opportunities for counselling men and couples (19, 106, 107). In a trial of home-based HTC for household members of an index ART-patient, a higher proportion of men in the clinic arm tested HIV-positive relative to the home-based HTC arm (18% vs 5%) (154).

In my field research in Zambia, 52% (95%CI: 49%-56%) of men in 2011/12 had ever-tested for HIV. By 2013, 61% (95%CI: 58%-64%) ever-tested and received the result of an HIV-test (Table 10) (14, 26). Levels of recent-testing were 25% and 31% (p<0.01), respectively (26). There were disparities in HIV-testing by age and sex, and across study sites. Almost 60% of ever-testers reported multiple lifetime HIV-tests (14). In both surveys, 50% of men accepted an offer of home-based HIV-testing among whom 5% tested HIV-positive (14, 26). Some 60% of men testing HIV-positive had never-tested or reported themselves HIV-negative yet the number of men newly diagnosed was small in both surveys.

The factors associated with ever-testing were similar to those associated in the years prior to the expansion of PITC and VCT, and the increased ART availability (Table 10) (26). Older men were more likely to have tested. Men aged 15-19 and ≥40 years were less likely to recently-test (26). Men with a history of TB treatment were more likely to ever-test. Reporting a religion was associated with ever- and recent-testing, and higher levels of education and employment with recent- and frequent HIV-testing (14). There was little evidence that the scale-up of VMMC services increased men's levels of HIV-testing. Most circumcised men were offered and accepted PITC in VMMC clinics. Half the circumcised men were estimated to have tested for HIV prior to their circumcision. There was little evidence that VMMC service scale-up contributed to increasing HIV-testing among men not opting for circumcision or the frequency of HIV-testing among circumcised men.

Table 10. Summary of findings: levels of HIV-testing and factors associated with HIV-testing outcomes, 2011/12 & 2013 surveys

	2011/12 Survey			2013 Survey			
	Ever-tested	**Recently-tested[1]**	**HBHTC[2]**	**Ever-tested**	**Recently-tested[3]**	**Multiple-testing[4]**	**HBHTC[3]**
Prevalence among all men (%)	52	25	53	61	31	35	48
Difference between females and males (%)	24	14	-	23	13	-	-
Factors associated with outcome	Age, education, marital status, religion, TB treatment history, spouse ever-tested & household SEP		Age, history of TB, district	As in 2011/12 & including household head, employment & ART availability	Occupation, religion, spouse currently pregnant	Age, education employment, HIV-status, cluster-level HIV-prevention knowledge	Age, household head, period of being absent, HIV status, spouse ever-tested
Did VMMC scale-up increase?	-	-	-	No	No	No	-

Footnote: HBHTC – accepted the offer of home-based HIV-testing; Factors associated with HIV-testing outcomes are those independently associated at the p<0.05-level. [1] Factors associated with recent-testing relative to never-testing; [2] Factors associated among all men; [3] Factors associated among ever-testers; [4] Factors associated with multiple-testing relative to never-tested are similar to ever-tested, those in table are relative to men testing once

10.2 Strengths and Limitations of the Research

This thesis includes the first systematic review of interventions to increase men's HIV-testing and provides evidence on how effective these strategies are at increasing men's uptake of HIV-testing (19). The strengths and limitations of the systematic review are presented in the manuscript (19). In this section I focus on the strengths and limitations of the methods used in Research Papers II-IV. Research Papers II-IV describe two large, well-conducted population-based surveys that included a relatively large number of men. The surveys were conducted according to a standard protocol in each study site. Research into men's HIV-testing behaviours has been limited compared to women's (57, 155, 156). This research contributes to this limited evidence, providing a longitudinal analysis of men's HIV-testing between 2011/12 and 2013 in three rural Zambian districts.

10.2.1 Measurement Error

HIV-testing outcomes were self-reported and retrospective, and may be subject to social desirability and recall bias (14, 26). Men may have over-reported a history of ever-testing for HIV. This bias may have been greater in certain sites and differential dependent on characteristics of the RAs, which may contribute to the observed level of variability in outcomes across study sites.

Men may have mis-reported dates of first and most recent HIV-test through inaccurate recall (14). Misreporting the date of their most recent HIV-test may have led to errors in the measure of recent-testing. Error in the measure of multiple-testing is subject to recall bias if men reporting themselves as living with HIV were more likely to recall the test in which they received their HIV-positive diagnosis. Multiple-testing among men living with HIV may be underestimated (14).

Independent variables may also be subject to measurement error. For example, couples were linked by matching women listed on the household enumeration form to the number of their spouse as listed on the form. In both surveys, some 40% of men who reported themselves married were not linked to spouse (14, 26). If the HIV-testing behaviours of the women linked to their spouse differed from women that were not linked, then the association between women's testing and men's may be biased (14).

As another example, men were asked whether VMMC services were available at the local health facility or through outreach/mobile services in their community. Men may have interpreted "outreach" to include hospitals or they may not have considered the local health facility as defined in the survey as their local health facility. Men in sites where services were not delivered may have been more likely to report service availability by other providers in neighbouring sites. It is, however, difficult to know the extent of this bias.

The definition of where VMMC services were scaled-up may have been subject to error. Services may have been promoted in sites where SFH did not report delivering any VMMC services. Lack of delivery may reflect limited demand for services. Furthermore, there may have been alternate services providers scaling-up VMMC in sites where SFH did not report delivering services. The implications of these errors are discussed in section 10.2.3.

10.2.2 Missing Data

In both surveys, a high proportion of men were absent during the household visit. The majority (>90%) were listed as present in the household over the entire recall period. Participating men differed from non-participants in factors associated with HIV-testing. There may have been unobserved factors associated with HIV-testing and participation, which would bias the outcomes.

To investigate and correct outcomes for this potential bias, I used Heckman-type selection modelling to investigate whether there was evidence for unobserved factors influencing participation and HIV-testing (Annex 5). I found little evidence for unobserved factors. Outcomes were similar after adjustment for non-participation. These models were subject to limitations. Results need to be interpreted with caution. My selection variables were not strong predictors of participation and were non-randomly allocated, thus limiting my certainty that they were not causally related to the outcomes (14). It is plausible that teams were more likely to visit, in the morning, study sites where households were dispersed to ensure they reached all households before they left for farming or other activities. If residents in these areas had less HIV-related knowledge and lower levels of HIV-testing, in the absence of data to control for HIV-related knowledge of non-participating men, time of the survey may have been related to HIV-testing outcomes. A further limitation is that I had limited individual-level data on non-participants. The models had limited precision in estimating the correlation between the unobserved factors influencing HIV-testing and participation (rho) (14) and the predicted outcomes among non-participating men.

10.2.3 Confounding

In the absence of data on all potential confounders or inaccurate data on confounders, residual confounding may be present in the associations estimated in this thesis. For example, associations may be subject to residual confounding by age. I opted to use 10 year age brackets for men aged over 19 years. However, age was strongly associated with education and marital status and with HIV-outcomes. As such, these age brackets may have been too wide and the associations between these variables and HIV-testing subject to residual confounding. Using smaller age brackets may, however, have affected my study's power to detect associations of interest.

Similarly, the education categories may have masked variation in levels of education within categories, leading to confounding in the associations between HIV-testing and employment. Considering the strength of the association it is unlikely that residual confounding would have had a large effect on these associations. Associations may be subject to confounding by unmeasured characteristics. For example, the association between multiple-testing and employment may be confounded by unmeasured characteristics that influence employment and access to HTC services, such as distance to commercial centres where employment and health services were likely available. The association between religion and HIV-testing outcomes may be confounded by unobserved characteristics that influence whether men report themselves as affiliated with a religion and test for HIV.

Prior to the analysis of the effect of the scale-up of VMMC services on population-levels of HIV-testing, I had expected that any effect would be subject to confounding as services were non-randomly allocated. The analyses found no effect of VMMC services on HIV-testing. Although confounding may still be a limitation, in light of the rapid scale-up of services from 2012 onwards, a limitation was likely the potential for contamination. At the time of the study, SFH was the main service provider in the study area, however, services were available at ZNS facilities and through other NGOs, with services promoted at national-level (157). The men residing in sites defined as comparison sites may have been exposed to activities to promote VMMC services.

A complementary measure of exposure to VMMC service scale-up might have been to ask men whether they had seen VMMC promotional activities, what activities they had been exposed to and the frequency of exposure. However, these measures may have been subject to error and recall bias, with circumcised men more likely to recall exposure to promotional activities. Using self-reported circumcision as a proxy for exposure to scale-up similarly found little evidence for an effect.

10.2.4 Temporality

Data from cross-sectional surveys are useful for exploring associations but cannot establish temporal relationships between variables. HIV-testing behaviours, education, a period of being absent from the household and a history of TB treatment were collected retrospectively. In contrast, SEP, religion and employment were measured at the time of the survey. Some variables may have been misclassified at the time of the survey. To give an example, studies have shown that migrant populations are less likely to test for HIV (158), yet I found little evidence of an association between a period of being absent and HIV-testing outcomes. At a different time point, men might have been classified differently. Any association with absenteeism may have been missed in this research due to misclassification.

Reverse causality is also a threat in cross-sectional surveys. Reverse causality occurs when the outcome itself causes an independent variable. I hypothesised that reverse causality would be limited, as it seemed unlikely that HIV-testing would be a cause of the variables explored. Nonetheless, among men linked to a spouse, I hypothesised that a spouse testing might influence men's HIV-testing. However, men's HIV-testing may have actually preceded their spouses first HIV-test. Considering the evidence that ANC-based services are effective at reaching men, it seems unlikely that most men were HIV-tested before their spouse. In Research Paper IV, I hypothesised that VMMC service scale-up would increase knowledge of service availability and of the relationship between HIV and circumcision, encouraging men to test for HIV. However, testing for HIV may have led to increased knowledge rather than the reverse.

10.2.5 Lack of data on sexual behaviours

No data were available on men's sexual behaviours, limiting the ability to explore whether the men reporting multiple HIV-testing "needed" to test more frequently or were "worried well" (14, 159). However, men living with HIV were less likely to report multiple HIV-tests before their diagnosis suggesting that men with an ongoing risk of infection and therefore in need of annual HIV-testing are not testing frequently (14).

10.2.6 Generalisability

At the time of the 2013 survey, the BHOMA intervention had been implemented in the study area. Although HIV-testing was not an outcome of BHOMA, with increased availability of community healthcare workers and ongoing mentoring and training of health care workers, more men may have accessed the health facilities and been offered PITC. The increase in HIV-testing among men in the 2013 survey may reflect implementation of this intervention.

10.2.7 Systematic Observation

Direct observation is commonly used in qualitative research when the objective is to explore how a system works and how individuals interact with the system (160). Examples of direct observation in quantitative research include explorations of the relationship between the built environment and health outcomes in Australia, Brazil, Canada, the Netherlands, the UK and the USA (126, 161-165). In this study, observations were conducted uniformly and systematically in all study sites. I found little evidence for widespread of VMMC service promotion. Due to logistic and financial constraints, observations were conducted once in each site. If no promotion activities were identified on the day of the observation this does not preclude the possibility that a promotional campaign was conducted the week or even the day before. The observations focused primarily on posters to increase the sensitivity of identifying places where VMMC promotion had been conducted. However, VMMC service promotion did not rely as heavily on posters as expected, limiting the ability of the observations to provide data on where services had or had not been promoted and little scope to explore the association between the level of service promotion and population-levels of HIV-testing.

Time and financial constraints limited the ability to conduct an assessment of the reliability of the systematic observations. In the absence of such constraints, a random sample of study sites per district would have been selected and an independent team employed to determine inter-observer reliability, particularly with regards to promotion outside of the health facility.

10.2.8 Summary

In summary, my study provides the first systematic review of the effectiveness of interventions to increase HIV-testing on men's uptake of HIV-testing in sub-Saharan Africa. My field studies used large, well-conducted surveys to provide an investigation into men's HIV-testing behaviours over an 18 month period during which time alternate HTC strategies were available. Limitations of the field studies include high levels of missing data and the potential for measurement error. The study was unable to assess causal relationships between independent variables and outcomes, and associations may be subject to residual confounding.

10.3 Discussion of the Findings

Effective approaches to reach men with HTC services are available (19), with different strategies effective at reaching different sub-populations of men. Simple interventions implemented through ANC can increase HIV-testing among men with a pregnant partner attending ANC. The pooled risk ratio of three trials included in the systematic review was 2.0 (95%CI: 1.1-3.8; Annex 6) (26, 149, 151, 166). In two trials, ANC attendance was associated with women's HIV-positive status (149, 151). In the Ugandan trial, the majority of men HIV-testing tested negative (166). In the South African trial, 53% of men across both arms tested HIV positive (149). In a Kenyan RCT published after the review, home-visits increased HIV-testing among men compared to invitations for males to attend ANC (85% versus 36%; RR=2.4; 95% CI: 1.9-3.0) (167). HIV prevalence among men was similar in both arms (12% vs 8%, p=0.2) (167). Some 15% of couples were sero-discordant in the home visit arm compared with 5% in the control arm (p<0.01) (167).

In the CRT of mobile HTC with community mobilisation and post-test support in Tanzania and Zimbabwe, 55% of individuals reached through mobile services were male (153). In a CRT comparing home- and mobile-HTC in Lesotho, 23% of individuals reached through mobile services were males aged 12 years or older (168). The lower representation of men in Lesotho may reflect how services were delivered. Services were delivered weekdays between 9am to 5pm in tents at a "pitso", commonly used to deliver antenatal consultations and malnutrition screening for children (168), and promoted through groups talks to men, women and children on the day of service availability. These findings iterate that the approach to delivering services is critical to reaching men.

My study contributes to the evidence that alternative methods of delivering HTC services have increased Zambian men's HIV-testing. With the implementation and promotion of couples HTC and community-based HTC, an increase in men's levels of HIV-testing was expected. However, levels of HIV-testing in this rural Zambian setting were higher than anticipated. In a 2010/11 survey in South and Central Province, Zambia, in which over half the respondents resided rurally, 36% of men ever-tested for HIV (169). In Tanzania (2011), where levels of HIV-testing have historically been higher relative to other sub-Saharan African countries (1), 54% of men ever-tested (170). At the time of writing, the 2013/14 Zambian DHS was published (171). In Lusaka province, 61% of men ever-tested for HIV and 33% tested and received the results of an HIV-test in the past 12 months (171). Levels were similar in this research. Efforts to provide Zambian men with access to HTC services have been successful, with, the NASF 2011-2015 target for 30% of men reporting a recent-test reached in 2013 (139).

In the 2013 survey, some 3% of men reported ever-testing but never receiving the result of an HIV test. In studies conducted when HTC relied primarily on VCT, some 25% of individuals did not return to collect their HIV test result (172). HTC services aim to change behaviours through the offer of counselling based on the result of the HIV test result. In the absence of receipt of test result and post-test counselling, HTC is unlikely to reduce risky sexual behaviours (51). The development of rapid HIV tests and the delivery of HIV testing services through community-based models have facilitated reducing the proportion of individuals who do not receive their HIV test result. With more individuals tested and provided with the result of an HIV test alongside risk reduction counselling, current HTC services may prove more effective at facilitating behaviour change relative to more traditional models of HTC service delivery (173).

Despite progress in reaching men, my research highlights that there remains a gender gap in levels of HIV-testing (Table 10) (1). In my study, difference in HIV-testing outcomes by sex remained stable. Women's levels of all outcomes were roughly 40% higher than men's. In the 2013/14 Zambian DHS, women's levels of ever-testing in Lusaka (82%) were 34% higher than men's, and recent-testing 40% higher (171). In a cohort study in South Africa (2006-2010), women's and men's HIV-testing increased over time yet the gender gap in HIV-testing remained stable at roughly 24% (52). In repeat surveys in Western Cape, South Africa, 40% of individuals ever-tested in 2004 increasing to 70% in 2008 (174). Some 29% tested during pregnancy in both surveys; VCT uptake increased from 26% in 2004 to 43% in 2008. Males were more likely to access VCT than females (174). Similar to my study, these findings suggest that the expansion of HTC services has provided men with access to HIV-testing.

Similar to studies in South Africa (60) and Kenya (175, 176), more than half the ever-testers in this study reported multiple lifetime HIV-tests (14). Few reported more than two lifetime HIV-tests and few men living with HIV reported testing prior to being diagnosed HIV-positive (14). Men at increased risk of HIV-infection may still only access HTC services when they feel unwell. In a cohort in Zimbabwe and surveys from Uganda and South Africa, "risk averse" individuals were more likely to test and repeat a test for HIV (51, 60, 155). In my study, some 60% of men testing HIV-positive in the rapid home-based HIV-test reported never-testing or –receiving the result of an HIV-test. In a 2009 national survey in Mozambique, 70% of men testing HIV-positive did not know of their HIV-status compared with 57% of women (177). To reach the first 90 of the revised UNAIDS 90-90-90 targets and maximise the prevention benefits of ART and HTC, a concerted effort is required to reach men who remain undiagnosed and increase the frequency of HTC among men at continued risk of HIV-infection (50, 60, 82, 111, 147, 178).

My study found that the factors associated with HIV-testing outcomes were similar to studies conducted prior to the expansion of HTC services, including age, marital status, religion, education, and employment (51, 58, 60, 155, 179). These characteristics have been associated with HIV-testing despite differences in study design, populations, measurement and definition of variables, and strategies to adjust for confounders. My findings are also similar to studies conducted in other countries since the expansion of HTC. In Tanzania (2011), never-testing was associated with younger age, being single and having no education (170). In my 2013 survey, 75% of men aged 30-39 years and 68% of men aged ≥40 had ever-tested for HIV. Some 37% and 30%

recent-tested, respectively. With HIV prevalence highest among this age group, it is promising that ever-testing was high among these men. However, recent-testing was lower among men aged ≥40 relative to men aged 20-39 years (26). There is a need to implement strategies to reach older men who may remain undiagnosed (180).

This study included males aged 15-19, defined as adolescents by the WHO (181). Studies have shown that adolescents are less likely to access HIV testing services relative to adults, with WHO estimating that some 10% of adolescent men in sub-Saharan Africa have ever-tested for HIV (181). In this study, some 30% of males aged 15-19 ever-tested. Although at lower risk of HIV-infection, HTC provides an opportunity for risk reduction counselling including recommendations for annual HTC if at continued risk of HIV-infection (146). Furthermore, some adolescents may have acquired HIV through mother-to-child transmission. Findings from this study highlight that there remains a need for research to develop and implement age-appropriate delivery of HTC services to reach younger males. With increased confidentiality and autonomy with regards to where to test for HIV, self-testing for HIV may prove a particularly appropriate and effective strategy to reach younger men (182, 183).

In Kenya, Namibia, South Africa, and Zimbabwe (1998-2007), HIV-testing was associated with increasing levels of education (51, 60, 176, 184). A survey of South African construction workers (2013) found a positive association between permanent employment and ever HIV-testing (185). My findings that education and employment were associated with recent- and multiple-testing among ever-testers are perhaps unsurprising. HTC service expansion may follow the "inverse equity hypothesis", developed in the context of inequities in child mortality and subsequently used to explore the social epidemiology of HIV (14, 26, 186-188). The theory posits that individuals of higher SEP are more likely to benefit from new interventions relative to individuals of lower SEP (186, 189). Increasing availability of HTC services in my study setting may have encouraged men with more education and employment to retest for HIV rather than reaching men of lower socioeconomic markers. Although subject to bias, studies in Malawi, Tanzania, South Africa and Zambia investigating the characteristics of individuals accessing mobile- or home-based HTC suggest that their reach is, in fact, equitable (190-193). In my study, acceptance of an offer of home-based testing was highest among men of lowest SEP (26). In the 2007 and

2013/14 Zambian DHS, HIV prevalence was highest among employed men, men with secondary or higher education and of higher SEP (117, 171). Studies in Zambia have, however, suggested that men with less education may be at increased risk of HIV-infection (194). The social epidemiology of HIV is complex (189, 195). Prevalence in groups of higher SEP may reflect survival through differential access to treatment (196). In support of equitable access for men requiring HTC services, there is a need to understand HIV risk by socioeconomic factors and monitor uptake of HTC through different service delivery approaches at different time points by these characteristics (111).

A consistent finding in my study was that men reporting no religion were less likely to test for HIV. These findings are similar to a cohort study in eastern Zimbabwe (2003-2008) and analyses of the 2005/6 Zimbabwean DHS: participation in a community-based organisation or affiliation to a religion was associated with testing for HIV among men (197, 198). Affiliation with a religious organisation may increase exposure to HTC service promotion or motivational messaging encouraging men to access HTC services. Alternatively, these findings may lend support toward the role of social networks in motivating men to test for HIV (67). In a study in Ndola, Zambia, friends and family played an important role in influencing adolescent males decisions to access HTC services (199). Qualitative research with men in Uganda found that friends and colleagues often encouraged men to access HTC services (69).

Neighbourhood context has implications for health outcomes and structural barriers are known to influence access to HIV prevention and treatment services (200-202). In my 2013 survey, multiple-testing was lower in sites with higher HIV-prevention knowledge and higher in sites where ART was available on the day of the health facility audit (14). Similar findings have been reported in other studies (60, 203). These findings point to the structural barriers that likely affect men's decisions to retest for HIV, including service availability and accessibility (67). In this study, HIV-testing was expected to be higher in sites where a higher proportion of men knew three measures to prevent HIV-infection and a higher proportion were employed (143). In an analysis of the 2001/2 Zambian DHS, women's HIV-prevention knowledge and men's employment levels were associated with married men's HIV-testing (143). Other than ART availability and HIV knowledge, my study found little evidence that measured characteristics of men's communities were associated with HIV-testing outcomes. District was associated with HIV-testing (26), with ever-testing highest in the smallest district. Outreach services may have been offered more regularly by the district health office and mission hospital due to fewer logistical constraints (26). With the NGO IntraHealth providing outreach HTC services since 2007, the higher prevalence of HIV-testing in this district may be attributable in part to this programme (2, 26).

Systematic reviews suggest that mass media campaigns can have short term effects on health outcomes, including uptake of HIV testing services (122, 123). A study in South Africa found that mass media programmes influenced HIV testing by influencing perceptions of the community levels of HIV testing services and conversations about HIV testing (204). In this study, systematic observation of VMMC-related promotion in each of the 42 study sites was expected to identify a variety of promotional activities. These observations, however, only identified posters and few posters were identified in each site. A quarter of men who reported that VMMC services were available in their community cited posters as a source of information. Although posters may contribute to awareness of service availability, they are unlikely to change men's norms around VMMC and HIV testing, or to alter their attitudes and perceived control over access to these services (124). As such, posters alone are unlikely to change men's intentions to undergo medical circumcision or to access HIV-testing services. Although subject to limitations, findings from this thesis suggest that posters are an ineffective tool to increase men's access to HIV prevention services. Further research to explore the utility of posters and other forms of promotion, including social networks, in encouraging men to access VMMC services and HIV testing services is warranted.

In Zambia, VMMC services were offered through health facilities and mobile sites with services promoted at individual- through to national-level (1, 119, 135). PITC should be offered to all males opting for VMMC, with consent obtained from parents/guardians of males aged <18 years. In this study, 80% of men were offered PITC and 96% accepted the offer. Similar to studies from Uganda (205, 206) and South Africa (207), half the males in this study reported being circumcised aged <21 years and most were single. It was unexpected that a relatively high proportion of men opting for circumcision would *not* be first-time testers. In a facility-based study in Lesotho, 65%

of males were tested in VMMC clinics (208). The study did not present data on yield, however, men testing HIV-positive were referred for CD4 cell count testing suggesting these men may have been newly diagnosed (208). Settings where VMMC is offered remain, therefore, important for providing men with access to HTC.

Four years after VMMC programme implementation in Rakai, Uganda, male circumcision prevalence was 29% (206). In the 2013/14 Zambian DHS, circumcision was 23% in Lusaka (171). At 6%, the prevalence of circumcision in my research was lower than expected and low relative to the provincial estimate. The DHS provincial estimate may, however, mask variation by district. As in studies in Uganda and South Africa (209, 210), VMMC-related knowledge in my study was high, with over half the men who had heard of VMMC agreeing that circumcision was partially protective against HIV. Yet, almost one-third of men did not know whether VMMC services were available in their community, few men cited VMMC clinics as a location to access HTC and only a quarter cited posters and family/friends as sources of VMMC information (Figure 10). Considering the low uptake of VMMC services and the lack of evidence for widespread promotion, it is unsurprising that I found little evidence in support of the hypothesis that the scale-up of VMMC services might contribute to increasing men's HIV-testing. In particular, lack of an indirect effect on HIV-testing is unsurprising and may have been an unrealistic expectation for this time period and rural setting, where VMMC was a novel intervention.

In summary, my thesis research adds to the evidence that the expansion of HTC services in Zambia has contributed to increasing men's levels of HIV-testing (14, 26). However, the factors associated with ever- and recent-testing remain similar to those associated with these outcomes prior to increased availability of HTC. My findings suggest that expansion of HTC services has failed to reach all men in need of HTC (26). Some 40% of the men testing HIV-positive through home-based HIV-testing reported never-testing for HIV. Few HIV-positive men had tested before the test in which they were diagnosed HIV-positive. Although acceptance of PITC before VMMC was high there was little evidence that service scale-up contributed to increasing men's levels of HIV-testing in this rural setting. These findings emphasise the need for more effective implementation of existing HTC services and the delivery of targeted strategies to reach men who remain undiagnosed and HIV-negative men with an ongoing risk of HIV-infection.

10.4 Recommendations to Increase Men's HIV-Testing in Zambia

Drawing on findings from my research, I recommend a five-point strategy to increase men's HIV-testing in Zambia (Figure 19). First, I recommend that women attending ANC be given a letter of invitation for their male partners to attend ANC for HTC and complementary services (19, 26, 146, 147). Zambian PMTCT guidelines state that women should be given information on partner HIV-testing and the importance of encouraging partners to attend ANC for HTC (202). A letter of invitation would shift the responsibility of inviting men to ANC away from the female. Improving men's uptake of HTC services within ANC will have benefits that extend beyond men's HIV-testing, including couples counselling, support for adherence to PMTCT interventions and treatment, of particular relevance with the implementation of Option B+ in 2013 (78, 79, 91, 203, 204).

To facilitate this process, district health offices should develop a standardised letter for distribution to health facilities. The letter should inform men that couples HTC, with support for mutual disclosure, is available and also provide details of alternate locations for individual- or couples-HTC that may be more acceptable to some men, including settings where VMMC is offered. To maximise the effectiveness of this strategy, structural barriers men face in accessing ANC need to be addressed (50), including perceptions that ANC is a "female" space and some healthcare workers attitudes towards men that may deter their use of services (164, 205). To provide services to men who fail to attend ANC despite invitations, home visits should be planned (164). The provision of home-based HTC may support reaching sero-discordant couples with HIV services (164). Healthcare workers should be trained on delivering counselling services to men and couples, and specific clinic hours held for couples HTC.

Figure 19. Summary of five-point strategy to increase men's uptake of HIV-testing in Zambia

Findings emerging from the research	Recommendations based on the findings
Men more likely to report ever- and multiple-testing if spouse ever-tested & to recently-test if spouse currently pregnant; few men attend ANC for HTC	1. Standard letter of invitation for male partners to attend ANC for HTC; address barriers to men's access to ANC; offer home visits to men not attending HTC despite invitations 2. Strengthen implementation of couples HTC in other settings, including settings where VMMC is offered, by training HTC providers on couples HTC
Uptake of PITC high among circumcised men but scale-up did not contribute to increasing population-levels of HIV-testing; little evidence of community-level promotion	3. Integrate VMMC with HTC for men in settings where VMMC services are offered; promote VMMC services as settings for men to access HTC; standardise receipt of leaflets for distribution to friends/family
HIV-testing varied across and within districts; employed men and men reporting a religion more likely to test for HIV; adolescents and older men less likely to test	4. Develop context-specific policies to deliver outreach HTC targeted at men; build partnerships with existing community-based organisations; deliver services in innovative settings and through mobile delivery, in workplaces, schools, depending on the setting and target population
Few posters targeted at men observed; Men living with HIV less likely to report multiple HIV-tests	5. Develop promotional activities targeted at men, including rebranding of "know your status" messaging to inform men that annual retesting for HIV is required if at continued risk of infection

The NASF 2011-2015 highlights couples HTC and counselling of sero-discordant couples as a "core" prevention activity (206). My second recommendation is to strengthen the implementation of couples HTC in additional clinical settings (19, 83, 207). To date, couples HTC in Zambia has largely been ANC-based (26, 202). Findings from this thesis that men are more likely to HIV-test if their spouse tested for HIV suggest that reaching men through their partners could be effective in other clinical settings. The implementation of couples HTC would provide an opportunity to reach non-pregnant couples with HTC and complementary services (83, 208). The female partners of uncircumcised males aged 15-49 years are a target group for VMMC promotion (118). Couples HTC should be implemented in VMMC settings and women informed that these services are available alongside VMMC. Healthcare workers in these settings should be trained on the provision of couples HIV-testing, counselling and support for mutual disclosure (78, 83, 209).

In my 2013 survey, most ever-testers reported that their last HIV-test was at a health facility (14). ART availability was associated with HIV-testing and acceptance of PITC in VMMC clinics was high. These findings indicate that men can be motivated to access facility-based services. My third recommendation is, therefore, to integrate VMMC with HTC services for men. Considering the level of investment in delivering VMMC through facility- and mobile settings, and through outreach in non-facility buildings, and that these are "male-friendly" services, it seems a missed opportunity not to leverage the availability of HTC within settings where VMMC is offered. Evidence from my study that men are more likely to test if their spouse ever-tested, if they were affiliated to a religion or employed, lends support to the evidence that men's decisions to test for HIV or go for circumcision are influenced by family, friends and work colleagues (69, 85, 190, 210, 211). Social networks can have positive influences on men's health behaviours and this opportunity needs to be leveraged. As such, men accepting PITC in VMMC settings could be instrumental in reaching friends/family who have never-tested for HIV, just as women accessing PITC in ANC have been instrumental in reaching their spouses. Men accessing VMMC should be offered leaflets to give to their friends/family with information on the services available in the integrated clinics and emphasise that these services are available to all men. Alongside integration, VMMC service promotion should advertise VMMC settings as places where all men can access HTC and complementary HIV-prevention services.

The Zambian NASF states that decentralisation of service delivery to district-level is key to the HIV response (137) and the HIV Investment Framework highlights community-centred design and delivery of services as a "programme enabler" (212, 213). Studies have shown that community groups can play a key role in HIV-prevention (188, 213). In my study, men with no education or employment were less likely to report HIV-testing outcomes. HIV-testing varied across and within districts. Levels of HIV-testing were highest in the most rural district served by a mission-supported hospital. These findings suggest that: 1) economic and logistical barriers, such as cost and distance, influence HTC uptake in this setting and 2) increasing the accessibility of services can contribute to increasing men's uptake of HTC. As mentioned, in my study men reporting no religion or employment were less likely to test. Social support networks likely influence men's HIV-testing behaviours (211). Taken together, these findings lend support to the role of community-based organisations in increasing men's HIV-testing in Zambia.

My fourth recommendation is, therefore, the promotion and delivery of targeted outreach HTC services in collaboration with community-based organisations (97). Collaboration with existing organisations not only facilitates reaching men who remain undiagnosed or whose sexual behaviours mean they are at continued risk of HIV-infection, it leverages the availability of existing resources, including knowledge of target populations. Services need to reach older men who remain undiagnosed and younger, less educated and unemployed men who may have less access to available facility-based services and be at an increased risk of infection. More effective targeting of services to peri-urban and urban areas with higher HIV prevalence is required.

District health offices should identify organisations already delivering HIV services or those that involve men. Organisations should be engaged from the design stage of the outreach programme and supported to provide men with information on when and where HTC services will be available (97). Such information should be given to men in group sessions at workplaces and in areas where men socialise prior to service delivery. In Project Accept in South Africa and Zimbabwe, collaboration with community organisations led to wider information dissemination and opportunities to address underlying issues influencing a community's HIV risk, including unemployment (214). HTC services should be delivered through collaboration with health facilities to ensure quality of services and support linkage to treatment and prevention services, including VMMC and couples HTC (97, 215). HTC should be offered through work-, school- and mobile-based services, depending on what is appropriate for the setting and target population (97). In my study, few men were found at home and a small number of men were newly diagnosed after accepting home-based HIV-testing. Although home-based HTC may be effective at reaching men with a pregnant partner it will likely prove less effective at reaching all men in need of HTC. Delivery of HTC services in more innovative settings, including in buildings used by community-based organisation or near bars, need to be explored. Strengthened collaboration with community-based organisations to reach men in Zambia could have benefits beyond increasing HTC uptake. Although not explored in this thesis research, issues such as alcohol, gender-based violence and masculinity norms that influence men's involvement in HIV-prevention and their female partners' risk of HIV could be addressed through these collaborations (215, 216).

The cost of an outreach approach targeted at men is likely to be high (217, 218), particularly if services are accessed by HIV-negative men at low risk of HIV-infection. However, this investment appears to be justified considering the inability of currently available HTC services to reach all men in need of HTC services and the consistent finding that men are diagnosed at later stages of HIV-infection (72, 219), and thus risk transmitting HIV to their uninfected partner (50, 72). Higher investments and more intense delivery in the early phases of the strategy will be required to reach men who currently remain undiagnosed. Annual assessments of the cost per newly diagnosed HIV-positive man will be required to support revising the strategy in response to HTC uptake and yield within different places and at different time points.

The fifth recommendation is a concerted effort to promote the availability of HTC services to men through mid-media, including posters and radio. In my study, few HTC-related promotional activities targeting men were observed. Couples-HTC related posters were observed in half the study sites. This likely contributed to normalising couples HTC and the finding that men's HIV-testing was associated with their spouse ever-testing. Promotion should highlight men's role in HIV-prevention, and the importance of couples HTC and annual HIV-testing among men with ongoing risk of infection (14, 143). Considering that men with less education were less likely to test for HIV and report being circumcised, and the variation in levels of HIV-testing by study sites, promotion needs to be accessible to men with lower health literacy and reach areas currently underserved.

10.5 Research Priorities

This thesis had limited ability to unpack the barriers to men's HIV-testing and the motivations for multiple-testing among half the ever-testers. Despite increasing availability and promotion of HTC services, a high proportion of men never-tested for HIV. As highlighted in Research Paper III, there remains a need to: 1) understand the structural barriers that men with less education and no employment face in accessing HTC services; 2) understand their risk of HIV-infection and 3) investigate strategies likely to be appropriate to reach these men (14).

New approaches to increase men's use of available HTC services are required (14, 26). Two strategies highlighted that warrant further exploration are self-testing and incentivised HIV-testing (26, 110, 220, 221). Evidence suggests that self-testing for HIV is feasible, accurate and acceptable to men (220, 222). There remains a need to understand how and where to deliver self HIV-testing kits to reach the highest number of undiagnosed men, whether men who opt for self-testing return for confirmatory HTC and are linked to appropriate services, and the implications on sexual behaviours among men testing HIV-negative in the absence of post-test risk-reduction counselling (220, 222, 223). One approach is providing HIV self-testing kits through ANC settings and/or in VMMC clinics (26). Men may find it more acceptable to attend ANC to collect a self HIV-test kit or to attend VMMC clinics that are specifically for men. A pilot study or trial exploring whether inviting men with a pregnant partner in this rural setting to obtain self-testing kits in ANC or VMMC clinics is more effective than a standard letter inviting men with a pregnant partner to access HTC in ANC is warranted.

There remain unanswered questions regarding the scalability, yield, cost and sustainability of incentivised HTC (26, 221). In my research, unemployed men were less likely to test for HIV. Economic barriers, among others, likely influence men's motivation to test for HIV. In Cape Town, South Africa, active door-to-door recruitment in combination with a voucher redeemable at a local supermarket provided 88% of recruited individuals with access to mobile HIV-testing (221). Incentivised HIV-testing could be delivered through ANC or VMMC settings to reach couples (26). Incentives could include mobile airtime, leveraging the widespread availability of mobile phones, and be sustained through a public-private partnership. Community- or group-level incentives to provide a combination of HIV-prevention services alongside other services, such as vocational training, could also be explored. Although direct financial incentives are unlikely to be appropriate, due to sustainability issues and concerns around coercion, material incentives may be appropriate. Incentivising behaviours is complex and remains a topic of debate. Its role in HTC and HIV prevention remains unclear (224). Feasibility studies to investigate acceptability, the risk for perverse incentives and negative outcomes need to be explored in Zambia alongside studies of the types of incentives that are effective at reaching men who remain undiagnosed (26).

An investigation into models of healthcare provider-assisted disclosure appropriate to Zambia should be considered (225, 226). In the Malawian trial included in Research Paper I (19), provider-notification in STI clinics was effective at reaching a high proportion of previously undiagnosed individuals (227). Although a small trial, partner-notification was acceptable and feasible, with little evidence for negative outcomes (225, 227). Approaches could include an invitation from providers to attend couples HTC, similar to the model to invite men to ANC, or leverage the availability of mobile phones (19, 151). Partner notification remains complicated and requires an understanding of the risk for intimate partner violence prior to the implementation of such strategy (225, 226). Nonetheless, it could be a promising strategy to reach undiagnosed men and those at increased risk of HIV-infection.

Increasing men's uptake of HTC services is critical to the HIV response. However, there is a need to address the broader context that influences men's risk of HIV and of transmitting HIV to their sexual partners. Interventions that reduce poverty and gender-based violence, and address harmful masculinity norms need to be developed, tested and combined with those to increase men's uptake of HTC services. Interventions that provide young, single men with adolescent-friendly services and supportive environments that allow them to adopt safer sexual practices are required (228). For men in a couple, there is a need to address norms that limit their involvement in couples-centred HIV-prevention with their female partners, including access and adherence to ART and sexual behaviours that influence younger female partners risk of HIV (208). Failure to address these underlying determinants of risk will limit the broader HIV prevention benefits of increasing men's uptake of HTC services.

Chapter 11. Conclusion

Available strategies to increase men's uptake of HIV-testing are effective. Progress has been made in providing men with access to HTC. Men's levels of HIV-testing have increased substantially since the 2007 Zambian DHS and significantly in the study area over an 18 month period (14, 26, 116). This increase, however, masks variation in levels of HIV-testing across study sites and there remain inequities in access to services by age, sex and markers of socioeconomic position. A high proportion of men remained unaware of their HIV-positive status despite efforts to scale-up HTC services.

VMMC services were scaled-up in over half the study sites. There was little community-level promotion and low uptake of services. Most circumcised men were offered PITC and accepted the offer. Yet, this thesis research found little evidence to support the hypothesis that VMMC service scale-up might contribute to increasing population-levels of HIV-testing in this setting. There was little direct effect as a high proportion of men opting to be circumcised had already tested for HIV. Lack of an indirect effect may be attributable to the low uptake of VMMC services, low levels of observable promotion within communities and/or the time period in which the research was conducted. Harnessing the potential of VMMC services to provide more men with access to HTC services is recommended as part of a five-point strategy to increase men's HIV-testing in Zambia.

Despite progress, concerted efforts are required to reach men with HTC. Some 40% of men never-tested for HIV and, in some sites, only 12% of men recently HIV-tested. Among men testing HIV-positive during rapid home-based HIV-testing, 60% had never-tested or reported themselves HIV-negative. In a five-point strategy to increase men's HIV-testing, leveraging the availability of existing services, including HTC in ANC and VMMC clinics, is recommended alongside the delivery of targeted outreach services through collaboration between district health offices, health facilities and community-based organisations. Research into innovative approaches, including self-testing and provider-assisted disclosure, to improve men's uptake of existing services is justified. Failure to reach men unaware of their HIV-positive status and increase the frequency of HIV-testing among HIV-negative men at risk of HIV has implications for the health of men and their female partners by limiting the success of proven HIV-prevention interventions.

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