AIDS and Behavior (2019) 23:1095–1103
https://doi.org/10.1007/s10461-019-02407-w

ORIGINAL PAPER

Application of an HIV Prevention Cascade to Identify Gaps in Increasing Coverage of Voluntary Medical Male Circumcision Services in 42 Rural Zambian Communities

Bernadette Hensen[1] · Elizabeth Fearon[2] · Ab Schaap[3,4] · James J. Lewis[3] · Helen A. Weiss[3] · Margaret Tembo[4] · Namwinga Chintu[5] · Helen Ayles[1,4] · James R. Hargreaves[2]

Published online: 8 February 2019

Abstract
Increased coverage of voluntary medical male circumcision (VMMC) is needed in countries with high HIV prevalence. We applied an HIV-prevention cascade to identify gaps in male circumcision coverage in Zambia. We used survey data collected in 2013 and 2014/15 to describe circumcision coverage at each time-point, and prevalence of variables related to demand for and supply of VMMC. We explored whether circumcision coverage in 2014/15 was associated with demand and supply among uncircumcised men in 2013. Results show that circumcision coverage was 11.5% in 2013 and 18.0% in 2014/15. Levels of having heard of circumcision and agreeing with prevention benefits was similar at both time-points (79.8% vs 83.2%, and 49.7% vs 50.7%, respectively). In 2013, 39.3% of men perceived services to be available compared to 54.7% in 2014/15. Levels of having heard of circumcision in 2013 was correlated with and higher perceived service availability associated with coverage in 2014/15. VMMC coverage was low in these study sites. Knowledge of prevention tools and of service availability are necessary to increase coverage but alone are insufficient.

Keywords Voluntary medical male circumcision · HIV prevention cascade · Zambia · Africa · HIV

Introduction

Between 2010 and 2016, the number of new HIV infections among individuals aged 15 years and older in eastern and southern Africa declined by 11% [1]. In the absence of a vaccine, ending the HIV epidemic by 2030 requires high coverage of anti-retroviral therapy (ART) and prevention strategies, including voluntary medical male circumcision (VMMC), in countries with a high burden of HIV [2]. By 2015, progress in reaching 80% VMMC coverage targets among males aged 15–49 years was variable across the 14 VMMC priority countries in eastern and southern Africa [1, 3]. In Zambia, where traditional circumcision is not widely practised, VMMC was officially launched in 2009 [4]. By 2016, 1.5 million males had been circumcised in Zambia, of whom an estimated 60% were aged over 15 years [5–8]. With Fast Track targets calling for 80% VMMC coverage among males aged 15–49 years by 2020, VMMC programmes need to target services effectively to increase coverage among older men, and men at higher risk of HIV [9, 10].

Recognising the need to increase VMMC coverage, studies have explored barriers to VMMC uptake and evaluated strategies to address these, including incentives [11–13], group information sessions for males and their female partners [14], tailored information through SMS-messaging [15], postcards with messages challenging masculinity norms [16], sports-based VMMC information and motivation sessions [17], and transport vouchers and VMMC information delivered to men through their pregnant spouse [18].

✉ Bernadette Hensen
Bernadette.hensen@lshtm.ac.uk

1 Clinical Research Department, Infectious and Tropical Diseases, The London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, UK

2 Public Health, Environments and Society, Public Health and Policy, The London School of Hygiene and Tropical Medicine, London, UK

3 Infectious Disease Epidemiology, Epidemiology and Population Health, The London School of Hygiene and Tropical Medicine, London, UK

4 Zambart, University of Zambia, Lusaka, Zambia

5 Society for Family Health, Lusaka, Zambia

Few of these strategies have been effective at increasing coverage, particularly among men aged 25 years and older [19].

HIV prevention cascades have been proposed as a framework to monitor and support programmes in increasing coverage of prevention products. The HIV prevention cascade provides a framework to measure coverage of a prevention product or behaviour, and to track gaps in coverage by measuring whether individuals are *supplied* with the prevention product; have *demand* for the prevention product; and are *capable of using and adhering* to an HIV prevention product [20]. Using data from Zimbabwe, Garnett et al. applied the cascade to identify gaps in VMMC coverage and found that, although service availability increased over-time, few men perceived themselves at risk of HIV, likely leading to low demand for services (with adherence over time not applicable to male circumcision) [21]. In this study, we describe levels of, and variation in, male circumcision coverage at two time-points (2013 and 2014/15) in 42 primarily rural sites in Zambia. In line with the HIV prevention cascade, we explore whether low coverage of male circumcision can be attributable to gaps in demand for male circumcision and perceived availability of VMMC services, and use programmatic data and systematic observations to describe actual service delivery and promotion. Using these demand and supply variables, we investigated whether higher levels of demand for and perceived availability of male circumcision services in 2013 were correlated with male circumcision coverage in 2014/15, and whether measured levels of service availability and promotion in 2013 were correlated with male circumcision coverage in 2014/15.

Methods

Study Location

This study used data collected from 42 predominantly rural study communities in three districts of Lusaka Province. The study communities were the catchment areas of 42 primary health care facilities.

Data Collection

This study used three data sources. The first was survey data for a cluster randomized stepped-wedge trial—the Better Health Outcomes through Mentoring and Assessment (BHOMA) trial [22]. The BHOMA intervention, described in detail elsewhere [22], was a health system strengthening intervention implemented in 42 health facilities in three predominantly rural Zambian districts. Increasing VMMC uptake was not an objective of, and not included in, the package of interventions delivered through BHOMA. However, data relevant to our purposes was nested within the surveys.

The BHOMA Surveys

We used individual-level survey data from the BHOMA midline survey (January–November 2013) and endline survey (November 2014–September 2015) [22]. Details of the BHOMA evaluation have been reported elsewhere [22]. Briefly, the BHOMA health systems strengthening intervention aimed to reduce under-5 mortality and all-cause mortality [22]. These primary outcomes were measured among households in randomly selected "blocks" using a household enumeration form. Using maps, a ~ 3.8 km radius was marked around each of the 42 health facilities, within this radius blocks of roughly equal number of households were drawn and numbered. The numbered blocks were randomly selected, and data were collected from individuals residing in households within these blocks [22]. The target sample size was 300 households in each study site. Data collection tools included household enumeration forms, and household and individual questionnaires.

Among the target number of households, ~ 40% were randomly selected for participation in a full survey, which, alongside household enumeration, included individual surveys for household members aged 15–59 years. The individual questionnaire included questions on demographics, health and access to health services. In this study, we restricted analyses to men and excluded men self-reporting their HIV-positive status.

Routinely Collected Data

Our second data source was routinely-collected data from a national VMMC implementer operating in the three study districts (Society for Family Health (SFH)). In Zambia, demonstrations of the delivery of VMMC started in 2007, with widespread scale-up launched in 2009 [4, 23]. At the time of the study, SFH was the main VMMC service provider across Lusaka province and operated primarily through public health facilities but also six outreach hubs nationally [23].

Systematic Observations

Our third data source was systematic observations of VMMC promotion between July and August 2013. To generate demand for and promote VMMC services in the study communities, SFH trained community health promotors who mobilised men and offered leaflets on VMMC translated into local language; conducted mobile video shows and road shows on the benefits of VMMC and where services could be sought; where community radio stations were available, SFH conducted radio programs to deliver information

on VMMC, and worked with community leaders, such as chiefs, to become advocates of VMMC. The Ministry of Health and other VMMC partners delivered information through mass media (radio, television and newspaper) and mid-media (community events, posters and radio) as per the Zambian Communication and Advocacy Strategy [4, 6].

For the observations, research assistants used a protocol and observation schedule to collect data on the number of VMMC-related posters and other promotional activities, including community announcements, observed at and around each health facility in one day in each of the 42 sites. This tool was guided by a tool used to observe alcohol advertising [24]. Observations focused primarily on print media (posters, leaflets), as these were more likely to be observed. Data were collected at the health facility, and within a 1.5 km radius of the health facility. This radius was selected for logistic and financial reasons, and because it was anticipated that most of the promotional activities would occur near the health facility. After completion of observations in the 1.5 km radius, observations were conducted in two randomly selected high-density areas outside of the 1.5 km but within a 3.8 km 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. The 3.8 km radius was selected to align with the BHOMA evaluation area.

Key Variables

Using data from both BHOMA individual surveys, we categorised men who did not self-report as HIV-positive as uncircumcised or circumcised and defined this binary variable of whether or not men were circumcised as coverage. We described whether men were circumcised under the age of 15, circumcised aged ≥ 15 before 2007 (when VMMC became available in Zambia), or circumcised aged ≥ 15 after 2007. Men missing data on circumcision status were dropped from the analyses.

We created variables related to each individual man's demand for VMMC, including whether men had heard of male circumcision and whether they agreed that it partially protected against HIV. We also created variables describing each man's perception of the availability of male circumcision services at the local health facility and/or through mobile/outreach services in the community. Men with missing data or refusing to respond to variables related to demand or perceived supply were coded as not knowing about male circumcision, whether it protected against HIV, or not perceiving services to be available.

Men reporting availability of male circumcision services were asked how they heard services were available, and could select more than one option from: (1) family member/friend; (2) healthcare worker at local facility; (3) community health worker; (4) poster/leaflets at the health facility; (5) newspaper/radio; (6) announcements in the community; (7) posters in the community; (8) leaflets given in the community; (9) peer education in church; (10) peer education in school; (11) other or (12) I don't know/refuse to respond. These options were grouped as: (1) Information, education, and communication (IEC) through the health facility or someone affiliated with a health facility (healthcare worker at local facility; community health worker; poster/leaflets at the health facility); (2) family/peers (family member/friend; peer education in church or school), (3) mass media (newspaper/radio), (4) IEC in the community (announcements; posters or leaflets given in community), or (5) other. We created cluster-summary variables describing the prevalence of each of these characteristics.

Using the routinely-collected programmatic data, we created variables for each site describing whether any male circumcisions had been performed between 2009 and 2013, and the number of months circumcisions had been performed in each site over this time period. Using the systematic observation data we identified, for each site, whether on the day of the observation VMMC service promotion was observed or not.

Analysis Strategy

We first estimated coverage of male circumcision across the 42 study sites at both time-points and present the site range in coverage. For each time-point, we present graphically the age at which men reported being circumcised. Accounting for clustering by study site and adjusting for age and district, we investigated, for each time-point, whether circumcised and uncircumcised men differed with respect to the variables related to demand for and perceived availability of male circumcision services. Restricting data to uncircumcised men not self-reporting as HIV-positive, we described the prevalence of variables related to demand for VMMC (defined as having heard of male circumcision and agreeing that male circumcision can reduce an HIV-negative man's risk of acquiring HIV), perceived availability of services, and how men heard of service availability at both time points. As with male circumcision coverage, we present the cluster-level mean and site range [where data were skewed, we also present the median and inter-quartile range (IQR)].

Using the programme data, we described the number of study sites where VMMC services were delivered between 2009 and 2013, and the number of months that services were delivered in these study sites. Using systematic observations, we described the number of study sites where VMMC service promotion was observed.

Finally, using a cluster-level analysis, we used linear regression to investigate whether cluster-level prevalence of

variables related to demand for VMMC measured among uncircumcised men in 2013, and perceived availability of services in 2013 among this group were correlated with coverage of male circumcision by 2014/15. We also investigated whether the number of months of delivery of VMMC services by SFH between 2009 and 2013 and observation of any VMMC-related promotional activities were associated with coverage of male circumcision in 2014/15. In the absence of service delivery or promotion data from 2014/15, we hypothesised that levels of service delivery and promotion in 2013 would be correlated with levels of delivery and promotion in 2014/15.

We first investigated whether there was statistical evidence for an association and present beta coefficients and p values from a likelihood ratio test. For continuous variables, we investigated evidence for a linear relationship. For all variables, we examined the unadjusted association, and subsequently, where there was evidence for an association ($p \leq 0.05$), adjusted for mean age in 2014/15 and cluster-levels of coverage of male circumcision in 2013 as both were assumed to be associated with the independent variables and predictive of male circumcision coverage in 2014/15.

Results

In 2013, 55.7% (n = 3449/6192) of men aged 15–59 enumerated in households invited to participate in a full survey were absent and 4.6% (n = 285/6192) refused to participate. Among consenting men, 4.3% (n = 101/2458) self-reported their HIV-positive status. Of the 2357 men, 0.2% (n = 3) were missing data on circumcision status. At cluster-level, a mean of 56 men per cluster participated in the survey (range 31–88).

Among the remaining 2354 men, 11.5% (n = 269) reported being circumcised. Of these, 38.3% (n = 103) were circumcised aged < 15, 4.8% (n = 13) were circumcised aged ≥ 15 but before 2007, and 56.9% (n = 153) were circumcised aged ≥ 15 since 2007 (Fig. 1). The cluster-level mean of male circumcision coverage was 11.5% (site range 0–23.5%).

Circumcision status was associated with demand for male circumcision and perceived availability of services: almost all circumcised men (n = 261/269; 97.0%) had heard of male circumcision compared to 78.5% (n = 1636/2085) of uncircumcised men ($p < 0.001$; Fig. 2). Among circumcised men, 82.5% (n = 222/269) agreed that circumcision could reduce men's risk of HIV infection compared to 48.6% (n = 1013/2085) of uncircumcised men ($p < 0.001$). Almost two-thirds (170/269; 63.2%) of circumcised men perceived VMMC services to be available compared to 36.9% (n = 769/2085) of uncircumcised men ($p < 0.001$).

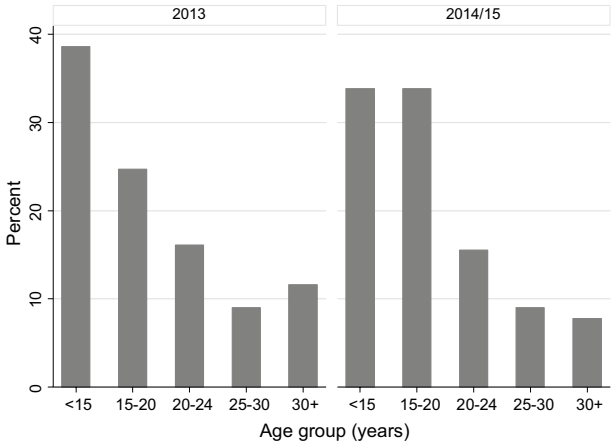

Fig. 1 Reported age (in years) at which men were circumcised by survey year (2013: N = 267; 2 men missing data on age in years but reported being circumcised aged > 15; 2014/15: N = 400; 1 man missing data on age in years but reported being circumcised aged > 15. Note this is age of circumcision regardless of calendar year in which circumcision occurred)

Among uncircumcised men, a cluster-level mean of 20.1% (site range 0–50.7%) had not heard of male circumcision and 50.3% (site range 19.5–80.6%) did not agree that male circumcision had HIV prevention benefits (Fig. 3; Table 1). Among the 39.3% (site range 4.3–78.9%; n = 769/2085) of men that perceived VMMC services to be available, half (53.3%) reported hearing about services through health facility IEC (range 0–100%), and 19.5% (range 0–66.7%) through peers/family members.

In the 2014/15 BHOMA survey, 46.6% (n = 2477/5312) of men aged 15–59 enumerated in households invited to participate in the full survey were absent and 9.3% (n = 496/5312) refused to participate. Five-percent of men self-reported their HIV-positive status (n = 105/2339; 4.5%) and 0.1% (n = 3) were missing data on circumcision status. Among the remaining 2231 men, 17.2% (n = 401/2231) of men reported being circumcised. At cluster-level, a mean of 53 men per cluster participated in the survey (range 26–75). Among circumcised men, 33.7% (n = 135) were circumcised aged < 15, 5.5% (n = 22) were circumcised aged ≥ 15 but before 2007, and 60.8% (n = 244) had been circumcised since 2007 and aged ≥ 15 years. Overall, circumcision coverage across sites was 18.0% (site range 1.8–44.4%). As in 2013, circumcised and uncircumcised men differed in variables related to demand and perceived service availability (Fig. 2).

At cluster-level, a mean of 16.8% (range 0–43.8%) of uncircumcised men had not heard of male circumcision and 49.3% (range 19.4–76.6%) did not agree with the prevention benefits of male circumcision. Relative to 2013, the gap in perceived availability of services narrowed, with 54.6% (range 15.8–87.5%; n = 1009/1830) of men reporting any

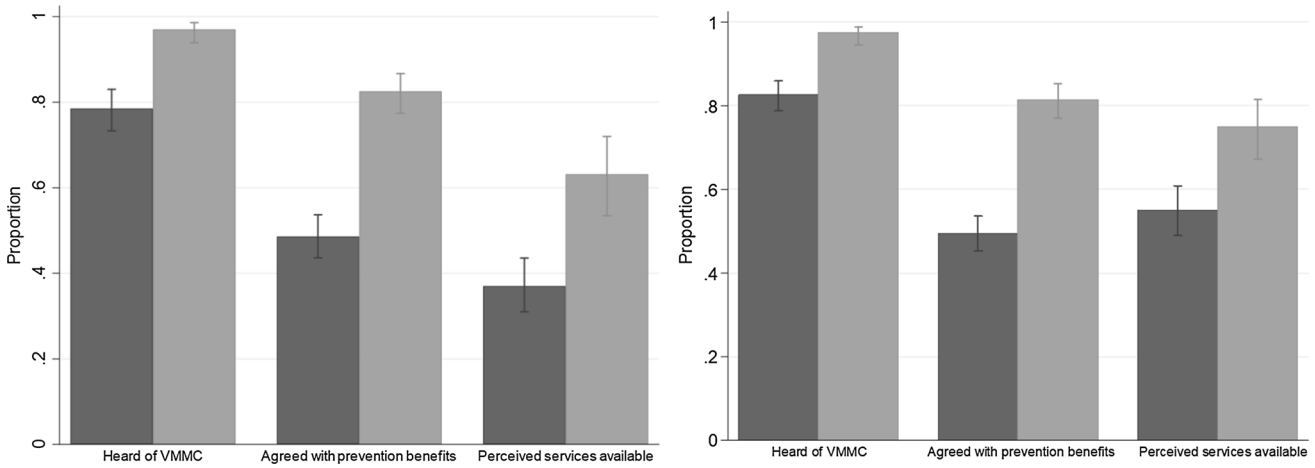

Fig. 2 Prevalence of variables related to demand for male circumcision services and perceived service availability by self-reported circumcision status, 2013 and 2014/15 (N = 2354 and N = 2331) (Key: Light grey = circumcised men, dark grey = uncircumcised men)

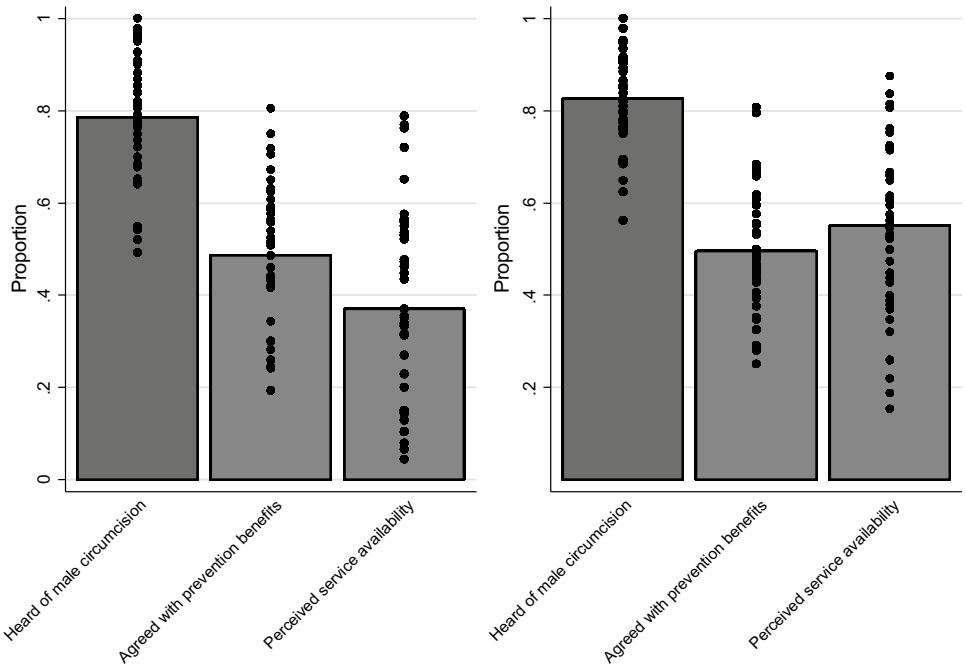

Fig. 3 Cluster-level determinants of demand for male circumcision and perceived availability of services among uncircumcised men in 2013 and 2014/15. Key: *VMMC* voluntary medical male circumcision, *HF* health facility, *bars* means of cluster-level summaries, *dots* individual study sites

availability of services in their community. Among men who perceived services to be available, a mean of 47.6% (range 0–100%) reported hearing about service availability through health facility IEC, 33.3% (range 0–100%) through friends/family members (Table 1).

Between 2009 and 2013, VMMC services were delivered in 25 of the 42 study sites according to data routinely collected by the primary VMMC provider in the districts. The median number of months services were delivered in these sites during this time period was 4.5 months (range 1–26). In 2013, posters promoting VMMC were observed in 50.0% (n = 21/42) of the study sites.

Table 2 presents results of the analyses of the correlation between the independent variables and male circumcision coverage in 2014/15 (the dependent variable of interest).

Adjusting for mean age and male circumcision coverage in 2013, there was strong statistical evidence that, on average, a percentage increase in knowledge of male circumcision in 2013 was associated with a 0.31-percentage point increase in male circumcision coverage in 2014/15 (r = 0.31; $p = 0.007$). For illustration, in sites where ≥ 80% of uncircumcised men had heard of male circumcision mean coverage of male circumcision was 21.7%, compared

Table 1 Variables related to demand for male circumcision and perceived availability of male circumcision services among uncircumcised men in 42 sites in Zambia, 2013 and 2014/15

	2013		2014/15	
Step in Cascade	Mean % (Median)	Range % (interquartile range)	Mean % (Median)	Range % (interquartile range)
Heard of male circumcision	79.8	49.3, 100	83.2	56.3, 100
Agreed with prevention benefits	49.8	19.4, 80.4	50.7	23.4, 80.6
Perceived services to be available (regardless of location)	39.3 (40.2)	4.3, 78.4 (IQR 20.0, 55.8)	54.7	15.8, 87.5
Perceived services available at local health facility	33.8 (30.4)	2.9, 76.3 (IQR 17.1, 51.3)	45.4 (46.3)	13.0, 81.4 (IQR 33.3, 59.6)
Perceived services available through outreach/mobile services in the community	28.2 (23.1)	1.4, 76.3 (IQR 13.0, 43.9)	44.2 (42.1)	7.3, 85.0 (IQR 29.6, 59.5)
How men heard of male circumcision service availability				
Health facility IEC	53.3 (56.9)	0, 100 (IQR 35.7, 72.7)	47.6 (39.1)	0, 100 (IQR 27.8, 77.1)
Friend/family member	19.5 (15.2)	0, 66.7 (IQR 4.5, 37.5)	33.3 (17.9)	0, 100 (IQR 5.7, 66.7)
IEC in the community	32.7 (26.1)	0, 100 (IQR 8.7, 51.7)	21.9 (10.6)	0, 69.2 (IQR 0, 42.9)
Radio/newspaper	12.8 (0)	0, 70.4 (IQR 0, 16.7)	6.2 (3.9)	0, 44.4 (IQR 0, 9.1)
Other	5.8 (1.4)	0, 66.7 (IQR 0, 7.7)	2.8 (0)	0, 16.7 (IQR 0, 4.8)

Table 2 Associations between male circumcision coverage in 2014/15 and cluster-level variables related to demand, perceived supply of male circumcision services, and actual delivery and promotion of voluntary medical male circumcision (VMMC) services in 2013 across 42 sites in Zambia

		Unadjusted β (95%CI)	Adjusted for mean age in 2013 β (95%CI)	Adjusted for mean age and VMMC coverage in 2013, and district β (95%CI)
Mean % of uncircumcised men having head of malecircumcision		0.27 (0.07, 0.48)	0.31 (0.11, 0.51)	0.31 (0.07, 0.55)
		(0.007)+	(0.002)$^{+}$	(0.007)$^{+}$
	p values	(0.03)*	(0.01)*	(0.03)*
R^2				0.38
Mean % of uncircumcised men agreeing with the prevention benefits of male circumcision		0.20 (0.02, 0.38)	0.23 (0.05, 0.41)	0.18 (−0.05, 0.40)
		(0.03)$^{+}$	(0.01)$^{+}$	(0.09)$^{+}$
	p values	(0.04)*	(0.03)*	(0.08)*
R^2				0.31
Mean % of uncircumcised men perceiving male circumcision services to be available		0.15 (0.01, 0.29)	0.18 (0.04, 0.31)	0.10 (−0.06, 0.26)
		(0.03)$^{+}$	(0.008)$^{+}$	(0.16)$^{+}$
	p values	(0.02)*	(0.002)*	(0.02)*
R^2				0.31
Number of months VMMC services delivered between 2009 and 2013		0.31 (−0.16, 0.78)		
		(0.18)$^{+}$		
	p values	(0.53)*		
Whether any promotion observed in 2013 (no/yes)		2.25 (−3.66, 8.17)	–	–
	p value	(0.43)*		

Key Outcome is prevalence of self-reported male circumcision in 2014/15; $^{+}$ p-value if for linear trend from likelihood ratio test (LRT); *pvalue for general association with categorical independent variable from LRT

to 12.9% where less than 80% had heard of male circumcision in 2013.

There was evidence that levels of perceived availability of services in 2013 ($p=0.02$) with little evidence that agreeing that circumcision has a protective effect ($r=0.18$; $p=0.08$) were correlated with male circumcision coverage in 2014/15. Service delivery between 2009 and 2013 and observed VMMC promotion in 2013 within the study clusters were not found to have an association with male circumcision coverage in 2014/15.

Discussion

In these 42 Zambian communities, coverage of male circumcision increased between 2013 and 2014/15 but remained low. Most men had heard of male circumcision, but the cascade identified a gap in knowledge of the protective effect of male circumcision. Across study communities, there was wide variability in demand for male circumcision and perceived availability of services. In sites where levels of knowledge of male circumcision and of perceived service availability was higher among uncircumcised men in 2013, levels of male circumcision were higher by 2014/15, even when accounting for earlier differences in coverage, age and district.

Our HIV prevention cascade analysis highlights gaps in coverage of a prevention intervention, and suggests areas for intervention. Our regression analysis found that cluster-levels of demand for male circumcision in 2013 were correlated with circumcision coverage in 2014/15. As the main service provider in the study sites, SFH likely contributed to increased demand for circumcision over-time. However, in the absence of a counterfactual, we cannot attribute increased demand or coverage to activities delivered by SFH. We found little change over-time in the percentage of men who agreed with the prevention benefits of male circumcision. To increase coverage, there is a need for continued investment in messaging to increase men's understanding of male circumcision, and its potential to reduce HIV risk [25]. In our study, and in line with the diffusion of innovation theory, [26] over-time more men reported that they heard of circumcision services through family/friends. Leveraging social networks may prove effective at increasing demand, particularly among older men who may be less likely to adopt a new technology [26]. In Zambia, a study of a peer-referral incentive intervention found no effect on demand for male circumcision, yet the study had limitations including in its design [27]. Peer-delivered interventions have shown effectiveness on condom use [27–30], and been used to deliver information on VMMC [14, 17]. Alternate peer-referral and -promotion strategies require exploration using rigorous study designs [27]. In these rural communities, targeted strategies that draw on existing networks between men and women [18, 19], should be considered.

Alongside demand, individuals need to be "supplied" with services that are available, accessible, and acceptable [20, 31]. We assumed that where services were delivered between 2009 and 2013 would correlate with delivery in 2014/15. Our study found no association between a measure of actual service delivery and male circumcision coverage in 2014/15. This may be due to the low intensity of service delivery, with services delivered for a median of 4.5 months over a five-year period, or the accessibility and acceptability of services, with studies showing, for example, that the sex of the service provider affects acceptability of services [32]. Our study did, however, find an association between perceived availability of services in 2013 and coverage in 2014/15. Service availability and providing information about services remains important. Yet, like demand, availability alone will not increase coverage if services are not acceptable or accessible or men cannot access them.

The third domain of the HIV prevention cascade is whether individuals are able to effectively use or adhere to the prevention product or behaviour [20]. Defining and measuring effective use is challenging and will be influenced by context; among the population in this study costs of accessing services and the opportunity cost associated with time off for healing post-circumcision may influence effective uptake [20]. Future applications of the HIV prevention cascade should consider how to define and measure factors that determine whether someone is able to use, or if applicable adhere, to prevention products [20, 28]. Interventions to address capability to take-up VMMC services have been implemented and tested, with variable success: in Kenya, a trial found that food vouchers increased circumcision uptake within two-months relative to control, though uptake remained low at < 10% [13]. A Zambian study exploring compensation for peer referral to VMMC in Southern Province found no effect [27]. Strategies that combine lessons learnt from interventions to address men's use with those to increase VMMC demand and supply should be considered, particularly to reach older men [33, 34].

Defining a single measure of demand for male circumcision is challenging. Previous studies measured men's intention or willingness to undergo circumcision [35, 36]. These variables do not necessarily reflect demand. In this study, demand variables only included measures of knowledge, which alone is not sufficient to generate demand. Studies show that cultural practices, masculinity norms, and fear of pain contribute to low coverage [5, 37–39]. Rather than measure a single variable for demand, defining and measuring core variables that influence demand is necessary, including social norms related to use, positive personal perceptions of the benefits of circumcision, and perceptions of need [20]. A better understanding of gaps

across these variables would support the development of more effective interventions.

This study and the data used have limitations. The population-based surveys were cross-sectional, and could only be treated as longitudinal at the cluster-level and not at the individual-level. Circumcision was self-reported. Studies have shown that circumcision is prone to over-reporting, our study may therefore overestimate levels of circumcision [40]. In both surveys, a high proportion of men were absent during the household visit. Heckman-type selection models on the 2013 data among men present in the previous month suggested no evidence of unobserved factors affecting participation and HIV testing outcomes [41]. Nonetheless, this study may be subject to bias if circumcised men were more or less likely to participate.

The survey may underestimate knowledge of service availability. The study communities were relatively contiguous, men were asked about services within their own community, however, at the time of the study, services were available at hospitals and provided by other non-governmental organisations in Lusaka city. Men may have travelled to access services, which may explain why we saw no association between service delivery and circumcision coverage. We had no data on sexual behaviours. In 2013/14, HIV prevalence was 13% among men in Lusaka and 8% in rural settings; HIV prevalence peaked at 23% among men aged 40–44 [42]. Not all men require VMMC; applications of the HIV prevention cascade should use data on sexual behaviours to restrict analysis to men at higher risk of HIV. Our data on service promotion likely underestimate promotion in the study sites, with data collected on only 1 day. Despite limitations, we used two cross-sectional surveys conducted at two time points, meaning our independent variables related to demand and service availability were measured prior to the dependent variable of male circumcision coverage in 2014/15.

Modelling studies show that high coverage of VMMC and early initiation of ART are critical to reducing HIV incidence in the absence of a vaccine [2]. By applying the HIV prevention cascade to existing data, our study showed that where more men had heard of male circumcision in 2013 was correlated with circumcision coverage in 2014/15, and that there was little change in knowledge of the protective effect of male circumcision. To increase coverage, a better understanding of the gaps within the cascade steps is required, with a focus on what influences men's demand for and capability to use services and how social and relationship networks can increase coverage of male circumcision.

Acknowledgements The authors would like to express their gratitude to the men who participated in the surveys, and the BHOMA community survey team leaders and research assistants.

Funding The BHOMA trial was part of the Africa Health Initiative launched by the Doris Duke Charitable Foundation (Grant# 2009060). Funding was provided by Economic and Social Research Council (Grant No. ES/J500021/1).

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

References

1. UNAIDS. UNAIDS Data 2017. 2017.
2. Smith JA, Anderson SJ, Harris KL, McGillen JB, Lee E, Garnett GP, et al. Maximising HIV prevention by balancing the opportunities of today with the promises of tomorrow: a modelling study. Lancet HIV. 2016;3(7):e289–96.
3. Voluntary Medical Male Circumcision for HIV Prevention in 14 Priority Ccountries in Eastern and Southern Africa. WHO; 2017.
4. National Voluntary Medical Male Circumcision Communication and Advocacy Strategy, 2012–2015. Lusaka, Zambia: Minidtry of Health; 2012.
5. Lukobo MD, Bailey RC. Acceptability of male circumcision for prevention of HIV infection in Zambia. AIDS Care. 2007;19(4):471–7.
6. National Male Circumcision Strategy and Implementation Plan 2010–2020. Lusaka, Zambia: Ministry of Health; 2009.
7. WHO. WHO Progress Brief: Voluntary Medical Male Circumcision for HIV Prevention in 14 Priority Countries in East and Southern Africa. 2017.
8. Zambia Country Report: Monitoring the Declaration of Commitment on HIV and AIDS and the Universal Access. 2015.
9. Dehne KL, Dallabetta G, Wilson D, Garnett GP, Laga M, Benomar E, et al. HIV Prevention 2020: a framework for delivery and a call for action. Lancet HIV. 2017;3(7):e323–32.
10. Fast-Track—Ending the AIDS epidemic by 2030. Geneva: UNAIDS; 2014.
11. Bazant E, Mahler H, Machaku M, Lemwayi R, Kulindwa Y, Gisenge Lija J, et al. A randomized evaluation of a demand creation lottery for voluntary medical male circumcision among adults in Tanzania. J Acquir Immune Defic Syndr. 2016;72(Suppl 4):S280–7.
12. Thirumurthy H, Masters SH, Rao S, Bronson MA, Lanham M, Omanga E, et al. Effect of providing conditional economic compensation on uptake of voluntary medical male circumcision in Kenya: a randomized clinical trial. JAMA. 2014;312(7):703–11.
13. Thirumurthy H, Masters SH, Rao S, Murray K, Prasad R, Zivin JG, et al. The effects of providing fixed compensation and lottery-based rewards on uptake of medical male circumcision in Kenya: a randomized trial. J Acquir Immune Defic Syndr. 2016;72(Suppl 4):S299–305.
14. Weiss SM, Zulu R, Jones DL, Redding CA, Cook R, Chitalu N. A cluster randomized controlled trial to increase the availability and acceptability of voluntary medical male circumcision in Zambia: the Spear and Shield Project. Lancet HIV. 2015;2(5):e181–9.
15. Leiby K, Connor A, Tsague L, Sapele C, Kaonga A, Kakaire J, et al. The impact of SMS-based interventions on VMMC uptake in

Lusaka Province, Zambia: a randomized controlled trial. J Acquir Immune Defic Syndr. 2016;72(Suppl 4):S264–72.
16. Wilson N, Frade S, Rech D, Friedman W. Advertising for demand creation for voluntary medical male circumcision. J Acquir Immune Defic Syndr. 2016;72(Suppl 4):S288–91.
17. Kaufman ZA, DeCelles J, Bhauti K, Hershow RB, Weiss HA, Chaibva C, et al. A sport-based intervention to increase uptake of voluntary medical male circumcision among adolescent male students: results from the MCUTS 2 cluster-randomized trial in Bulawayo, Zimbabwe. JAIDS J Acquir Immune Defic Syndr. 2016;72.
18. Semeere AS, Castelnuovo B, Bbaale DS, Kiragga AN, Kigozi J, Muganzi AM, et al. Innovative demand creation for voluntary medical male circumcision targeting a high impact male population: a pilot study engaging pregnant women at antenatal clinics in Kampala, Uganda. J Acquir Immune Defic Syndr. 2016;72(Suppl 4):S278–84.
19. Downs JA, Mwakisole AH, Chandika AB, Lugoba S, Kassim R, Laizer E, et al. Educating religious leaders to promote uptake of male circumcision in Tanzania: a cluster randomised trial. Lancet. 2017;389(10074):1124–32.
20. Hargreaves JR, Delany-Moretlwe S, Hallett TB, Johnson S, Kapiga S, Bhattacharjee P, et al. The HIV prevention cascade: integrating theories of epidemiological, behavioural, and social science into programme design and monitoring. Lancet HIV. 2016;3(7):e318–22.
21. Garnett GP, Hallett TB, Takaruza A, Hargreaves J, Rhead R, Warren M, et al. Providing a conceptual framework for HIV prevention cascades and assessing feasibility of empirical measurement with data from east Zimbabwe: a case study. Lancet HIV. 2016;3(7):e297–306.
22. Stringer JSA, Chisembele-Taylor A, Chibwesha CJ, Chi HF, Ayles H, Manda H, et al. Protocol-driven primary care and community linkages to improve population health in rural Zambia: the Better Health Outcomes through Mentoring and Assessment (BHOMA) project. BMC Health Serv Res. 2013;13(Suppl 2):S7.
23. Promising Practice Zambia: SFH Community mobilisation, mid media campaigns and national communications materials. 2014. https://www.malecircumcision.org/sites/default/files/document_library/Zambia_SFH_2_0.pdf.
24. Pasch K, Komro KA, Perry CL, Hearst MO, Farbakhsh K. Outdoor alcohol advertising near schools: what does it advertise and how is it related to intentions and use of alcohol among young adolescents? J Stud Alcohol Drugs. 2007;68:587–96.
25. Grund JM, Bryant TS, Jackson I, Curran K, Bock N, Toledo C, et al. Association between male circumcision and women's biomedical health outcomes: a systematic review. Lancet Glob Heal. 2018;5(11):e1113–22.
26. Rogers EM. Diffusion of innovation. New York: Free Press; 2003.
27. Zanolini A, Bolton C, Lyabola L-L, Phiri G, Samona A, Kaonga A, et al. Feasibility and effectiveness of a peer referral incentive intervention to promote male circumcision uptake in Zambia. J Acquir Immune Defic Syndr. 2016;72(Suppl 4):S262–8.
28. Krishnaratne S, Hensen B, Cordes J, Enstone J, Hargreaves JR. Interventions to strengthen the HIV prevention cascade: a systematic review of reviews. Lancet HIV. 2016;3(7):e307–17.
29. Medley A, Kennedy C, O'Reilly K, Sweat M. Effectiveness of peer education interventions for HIV prevention in developing countries: a systematic review and meta-analysis. AIDS Educ Prev. 2009;21(3):181–206.
30. Simoni JM, Nelson KM, Franks JC, Yard SS, Lehavot K. Are peer interventions for HIV efficacious? A systematic review. AIDS Behav. 2011;15(8):1589–95.
31. Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. Implement Sci. 2011;6:42.
32. Semo B-W, Wirth KE, Ntsuape C, Barnhart S, Kleinman NJ, Ramabu N, et al. Modifying the health system to maximize voluntary medical male circumcision uptake: a qualitative study in Botswana. HIV AIDS (Auckl). 2018;18(10):1–8.
33. Wambura M, Mahler H, Grund JM, Larke N, Mshana G, Kuringe E, et al. Increasing voluntary medical male circumcision uptake among adult men in Tanzania. AIDS. 2017;31(7):1025–34.
34. Ashengo TA, Hatzold K, Mahler H, Rock A, Kanagat N, Magalona S, et al. Voluntary medical male circumcision (VMMC) in Tanzania and Zimbabwe: service delivery intensity and modality and their influence on the age of clients. PLoS ONE. 2014;9(5):e83642.
35. Gurman TA, Dhillon P, Greene JL, Makadzange P, Khumlao P, Shekhar N. Informing the scaling up of voluntary medical male circumcision efforts through the use of theory of reasoned action: survey findings among uncircumcised young men in Swaziland. AIDS Educ Prev. 2015;27(2):153–66.
36. Mavhu W, Buzdugan R, Langhaug LF, Hatzold K, Benedikt C, Sherman J, et al. Prevalence and factors associated with knowledge of and willingness for male circumcision in rural Zimbabwe. Trop Med Int Heal. 2011;16(5):589–97.
37. Khumalo-Sakutukwa G, Lane T, van-Rooyen H, Chingono A, Humphries H, Timbe A, et al. Understanding and addressing socio-cultural barriers to medical male circumcision in traditionally non-circumcising rural communities in sub-Saharan Africa. Cult Health Sex. 2013;15(9):1085–100.
38. Rupfutse M, Tshuma C, Tshimanga M, Gombe N, Bangure D, Wellington M. Factors associated with uptake of voluntary medical male circumcision, Mazowe District, Zimbabwe, 2014. Pan Afr Med J. 2014;19:337. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4405072/.
39. Skolnik L, Tsui S, Adamu Ashengo T, Kikaya V, Lukobo-Durrell M. A cross-sectional study describing motivations and barriers to voluntary medical male circumcision in Lesotho. BMC Public Health. 2014;14.
40. Hewett PC, Haberland N, Apicella L, Mensch BS. The (Mis) Reporting of male circumcision status among men and women in Zambia and Swaziland: a randomized evaluation of interview methods. PLoS ONE. 2012;7(5):e36251. https://doi.org/10.1371/journal.pone.0036251.
41. Hensen B, Lewis JJ, Schaap A, Tembo M, Vera-Hernandez M, Mutale W, et al. Frequency of HIV-testing and factors associated with multiple lifetime HIV-testing among a rural population of Zambian men. BMC Public Health. 2015;15(960).
42. Central Statistical Office, Ministry of Health and II. Zambia Demographic and Health Survey 2013-14. Rockville, Maryland, USA: CSO and Macro International Inc.; 2014.