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Relative efficiency of demand creation strategies to increase voluntary medical male circumcision uptake: a study conducted as part of a randomised controlled trial in Zimbabwe

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ABSTRACT

Background Supply and demand-side factors continue to undermine voluntary medical male circumcision (VMMC) uptake. We assessed relative economic costs of four VMMC demand creation/service-delivery modalities as part of a randomised controlled trial in Zimbabwe.

Methods Interpersonal communication agents were trained and incentivised to generate VMMC demand across five districts using four demand creation modalities (standard demand creation (SDC), demand creation plus offer of HIV self-testing (HIVST), human-centred design (HCD)-informed approach, HCD-informed demand creation approach plus offer of HIVST). Annual provider financial expenditure analysis and activity-based-costing including time-and-motion analysis across 15 purposively selected sites accounted for financial expenditures and donated inputs from other programmes and funders. Sites represented three models of VMMC service-delivery: static (fixed) model offering VMMC continuously to walk-in clients at district hospitals and serving as a district hub for integrated mobile and outreach services, (2) integrated (mobile) modelwhere staff move from the district static (fixed) site with their commodities to supplement existing services or to recently capacitated health facilities, intermittently and (3) mobile/outreach model offering VMMC through mobile clinic services in more remote sites.

Results Total programme cost was $752 585 including VMMC service-delivery costs and average cost per client reached and cost per circumcision were $58 and $174, respectively. Highest costs per client reached were in the HCD arm—$68 and lowest costs in standard demand creation ($52) and HIVST ($55) arms, respectively. Highest cost per client circumcised was observed in the arm where HIVST and HCD were combined ($226) and the lowest in the HCD alone arm ($160). Across the three VMMC service-delivery models, unit cost was lowest in static (fixed) model ($54) and highest in integrated mobile model ($63). Overall, economies of scale were evident with unit costs lower in sites with higher numbers of clients reached and circumcised.

Conclusions There was high variability in unit costs across arms and sites suggesting opportunities for cost reductions. Highest costs were observed in the HCD+HIVST arm when combined with an integrated service-delivery setting. Mobilisation programmes that intensively target higher conversion rates as exhibited in the SDC and HCD arms provide greater scope for efficiency by spreading costs.

Trial registration number PACTR201804003064160.

Key questions

What is already known?

- Voluntary medical male circumcision (VMMC) is effective at reducing risk of female-to-male sexual transmission of HIV and is cost-effective.
- Supply and demand-side factors continue to undermine VMMC uptake, particularly among 20–35 years old, the age group at greatest risk of HIV.
- Longer-term financial sustainability of VMMC programming in an environment characterised by dwindling funding for HIV prevention is a key concern partly due to limited data on costs.

What are the new findings?

- Demand creation and communication costs constitute the majority of programme costs compared with VMMC service-delivery.
- Higher VMMC conversion rates provide greater scope for efficiency by spreading costs.

What do the new findings imply?

- High variability in unit costs across arms and sites suggests possible efficiency gains in VMMC service-delivery across various platforms.
- Intensified demand creation activities are needed to optimise uptake of VMMC and achieve optimal utilisation of inputs.

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INTRODUCTION

By 2007, three randomised controlled trials (RCTs) among over 11 000 men had shown that voluntary medical male circumcision (VMMC) was very effective at reducing risk of female-to-male sexual transmission of HIV and was cost-effective.[1–6] In the medium term, circumcising men ages 20–29 would yield the greatest reduction in HIV incidence, and over the long term, would result in the largest impact if infants or adolescent boys (≤19 years old) were circumcised.[7–9] Results of these analyses informed the 11 WHO/UNAIDS recommendations for VMMC scale-up in 14 high HIV prevalence countries in east and southern Africa (ESA) to maximise intervention effectiveness at a population level.[7] These priority countries, Botswana, Eswatini, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Rwanda, South Africa, Uganda, Tanzania, Zambia and Zimbabwe, now number 15 with the addition of South Sudan.[8]

Evidence shows that VMMC has continued to be a key contributor to HIV prevention and is cost-effective when provided to men most at risk (15–49 years).[9–16] Evidence from modelling work in Zimbabwe shows that the modelled cost per HIV infection averted in Zimbabwe fell to $811 when only men aged 20–24 years were circumcised from $1035 if targeting the broader 13–29 year age group. In South Africa and elsewhere, data suggest that VMMC cost-effectiveness decreases steeply with declining effectiveness of VMMC at higher ages.[17] This has an important impact and implications for the speed with which we can address the HIV epidemic and the sustainability of VMMC. By December 2019, and across the 15 VMMC priority countries combined, nearly 27 million adolescent and adult men had been circumcised and an estimated 340 000 new infections averted, including 260 000 infections among men and 75 000 among women (due to reduced secondary transmission from men).[7–11] Adult men (20–29 years), however, who are at greatest risk of HIV remain hard to reach as the majority of VMMC programme clients continue to be adolescent boys (≤19 years).[18–20]

In general, constraints to VMMC uptake across ESA vary but include both supply and demand-side factors. On the supply-side, VMMC uptake is restricted by shortages of both service-delivery sites and VMMC trained healthcare workers, a situation compounded by staff attrition.[21 22] Demand-side barriers include poor HIV risk perception and healthcare seeking among men; fear of pain associated with the surgical procedure and local anaesthesia; fear of surgical complications; fear of preoperative HIV testing, lengthy healing and sexual abstinence period and perceived threats to masculinity.[23–31] Low demand has also been associated with perceived high opportunity costs of seeking VMMC services including transport and productivity losses.[20 25 32 33]

For Zimbabwe, one of the countries' worst affected by HIV, with a prevalence of 12.9%, modelling studies suggested that the greatest reduction in new infections could have been achieved if 1.3 million (80% of 13–29-year-old men) had been circumcised by 2017.[6 20 34] In pursuit of these objectives, the VMMC programme had reached only 842 695 men (all ages) by December 2016; certain 'groups' such as higher-risk men aged 20–29 remained elusive. Higher risk adult men (20–29 years) only constituted 22% of VMMC clients; 70% of circumcisions were among 10–19 year-olds. Data suggest that the proportion of clients over age 20 years has decreased while the proportion aged 10–14 and 15–19 years either increased or stabilised over time.[20] Although circumcision numbers had increased to 1 157 000 (89%) men (all ages) by December 2017, they remained below target (though achieved by 2018) leading to revision of the original programme 'scale-up' phase—80% of 15–29-year-old men and 30% of 10–14 year-olds—to 2021.[35] More innovative, robust and cost-effective demand creation strategies are clearly required in order to reach the desired scale and reach men>20 years and optimise the impact of VMMC on HIV incidence.[6 13 36] Of concern for policymakers, programmers and funders scaling up VMMC, there is limited evidence on what works best for VMMC demand creation.[30 37]

A Ugandan programme recruited and empowered pregnant women with a package of comprehensive VMMC information while aligning the 6 week postcircumcision period and postpartum sexual abstinence.[38] Elsewhere, interventions have increased uptake through the offer of either direct fixed financial compensation or lottery-based material incentives to men seeking circumcision at clinics in Kenya, South Africa and Tanzania, or small financial rewards to men referring others in Zambia.[39–42] A Tanzania trial following a locally tailored demand creation strategy including mass media engagement, community mobilisation and targeted service-delivery found these more effective and less costly in increasing uptake of campaign-delivered VMMC among men aged 20–34 years.[43]

In Zimbabwe, work to address barriers to VMMC uptake and better understand how to reach men has included market research using private sector methodologies to identify strategies to maximise VMMC programme impact by efficiently and effectively reaching high-risk men as well as sport-based behaviour change programming which included logistical and behavioural follow-up.[25 44] In this paper, we present results of an economic analysis to assess the relative efficiency of demand creation models as part of a RCT which assessed the effectiveness of a human-centred design (HCD)-informed approach combined with HIV self-testing (HIVST) in motivating men (15–29 years) to take up VMMC.[25] HIVST has been shown to increase testing coverage among previously unreached populations, such as men, than conventional HIV testing services and might help overcome men's fear of preoperative HIV testing and a positive result, allowing them to test in private prior to going to a VMMC health facility (even if it meant being tested again).[45–47]

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METHODS

Setting and study design

The trial design is described in more detail elsewhere.[25] In short, Population Services International (PSI) Zimbabwe redesigned their interpersonal communication (IPC) demand creation approaches drawing on market research and using HCD-informed methods as discussed above. HCD approaches develop solutions to problems by involving the human perspective in all steps of the problem-solving process.[23–25] A 2×2 factorial pragmatic RCT compared arms with and without two interventions implemented by VMMC mobilisers known as IPC agents: (i) standard demand creation (SDC) augmented by HCD-informed approach; (ii) standard demand creation plus offer of HIVST across five rural districts (Buhera, Gokwe North, Mangwe, Mutasa, Zvimba) in 4 of 10 provinces in Zimbabwe, where neither the HCD-informed nor HIVST intervention had previously been implemented (table 1).[25] IPC agents, the unit of randomisation, were assigned 1:1:1:1 to four arms, using restricted randomisation. Restriction was based on IPC agent characteristics—sex, age and having ≥12 months of VMMC mobilisation experience. Each IPC agent was allocated to a specific geographic ward (a subunit of a district). All mobilised clients received a referral card to link the client to the IPC agent at the VMMC site.[25] Circumcised clients were therefore directly linked to their respective arm through the IPC agents who mobilised them. Online supplemental file 1 provides additional detailed narrative description of the demand creation models and mobilisation strategy.

Clients who agreed to be circumcised were offered VMMC services through three models (table 2): (1) static (fixed) model offering VMMC continuously to walk-in clients at district hospitals and serving as a district hub for integrated mobile and outreach services, (2) integrated (mobile) model where staff move from the district static (fixed) site with their commodities to supplement existing services or to recently capacitated health facilities, intermittently and (3) mobile/outreach model offering VMMC through mobile clinic services in more remote sites.[48] In addition to central and local government facilities, some of the static (fixed) VMMC sites comprised church-run mission hospitals which have traditionally served as district hospitals in a public-private partnership arrangement with Ministry of Health.

Monthly programme outcome data on the number of IPCs trained and active, number of clients reached and number of clients circumcised were obtained from the trial and used to estimate facility-level average cost per client reached or per circumcision.[25] From the 143 IPC agents identified by PSI, 140 were randomly chosen for the trial and allocated to one of four study arms. Postrandomisation, 20 declined to take part before training and were replaced by the implementer. Of the 132/140 (94.3%) who attended study arm-specific training, 105/132 (79.5%) reported reaching at least one client during the trial period and were included in the 'as-treated' analysis. The mean number of VMMCs/IPC agent over 6 months between SDC (average 34) and the HCD arms (average 35) remained steady although there was variability between and within IPC agents. IPCs reached a total of 12 929 clients (≥15 years old). Arm 1 (SDC) reached the highest number of clients (n=4937, 38%) while arm 4 (HCD +ST) reached the fewest (n=2327, 18%). Arms 2 (SDC + HIVST) and 3 (HCD) reached 2603 (20%) and 3062 (24%), respectively. Thirty-three per cent (4324 clients aged ≥13 years old) were circumcised. Arm 1 (SDC) resulted in the highest number of clients circumcised (n=1576, 36%) while arm 4 (HCD+ST) had the fewest circumcisions (n=636, 15%). Arms 2 (SDC + HIVST) and 3 (HCD) had 816 (19%) and 1296 (30%) circumcision procedures, respectively.

Costing overview

The primary costing objective was to measure the costs and assess the relative efficiency of implementing the four VMMC demand creation approaches. Full economic costs were estimated from the provider perspective following international costing guidelines for implementation between May and October 2018.[49–51] Costs of VMMC demand creation/service-delivery were analysed based on actual programme financial expenditures (top-down) including all start-up and initial training costs, incurred prior to launch of demand creation and facility-level data collection (bottom-up) at public health facilities to ensure the full value of all other resources used for VMMC service provision including clinic space and equipment; salaries and supplies were captured.[52–55] For this exercise, 15 facilities (n=5 per service-delivery model) offering VMMC services were purposively selected from the 5 RCT districts in order to estimate representative service-delivery costs retrospectively (12-month period). This exercise also accounted for any resources donated from other programmes and funders. Start-up, initial training and all other capital costs were annualised using the standard 3% discount rate (online supplemental table A2).[50–52]

Valuation of resources including those donated from other funders and programmes was done using National Pharmaceutical Company of Zimbabwe prices.[56–58] Data collection was conducted using a standardised set of study instruments adapted to the Zimbabwe VMMC setting from the PANCEA and ORPHEA projects.[53] The instruments included a facility questionnaire collecting information on several facility characteristics—type of facility, urbanicity, ownership (church vs public-sector run clinics) and annual number of clients served. The questionnaire was administered to facility in-charges or their nominees (other management staff or service providers).

Time and motion analysis, the gold standard for measuring staff allocation of time through direct observation, allowed us to get better estimates of staff time allocation devoted to VMMC services offered as part of integrated services at each of the 15 facilities.[59 60]

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Table 1 Overview of VMMC demand-creation models

	Standard demand creation	Standard demand creation + HIVST	HCD-informed approach	HCD-informed approach+HIVST
Type of cadre used for demand creation	► Trained IPCs ► Basic training on promoting VMMC as an additional HIV prevention intervention, identifying barriers, clarifying myths and misconceptions and summarising key benefits.	► Trained IPCs ► Basic training on promoting VMMC as an additional HIV prevention intervention, identifying barriers, clarifying myths and misconceptions and summarising key benefits.	► Trained IPCs ► Basic training on promoting VMMC as an additional HIV prevention intervention, identifying barriers, clarifying myths and misconceptions and summarising key benefits.	► Trained IPCs ► Basic training on promoting VMMC as an additional HIV prevention intervention, identifying barriers, clarifying myths and misconceptions and summarising key benefits.
Mobilisation design	► Standard mobilisation either as individuals or groups. ► Willing men booked, proceeded to VMMC sites individually or scheduled to meet at pick-up point and transported to nearest VMMC site.	► Standard mobilisation either as individuals or groups. ► Willing men booked, proceeded to VMMC sites individually or scheduled to meet at pick-up point and transported to nearest VMMC site.	► Standard mobilisation either as individuals or groups. ► Willing men booked, proceeded to VMMC sites individually or scheduled to meet at pick-up point and transported to nearest VMMC site.	► Standard mobilisation either as individuals or groups. ► Willing men booked, proceeded to VMMC sites individually or scheduled to meet at pick-up point and transported to nearest VMMC site.

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Table 1 Continued

	Standard demand creation	Standard demand creation + HIVST	HCD-informed approach	HCD-informed approach+HIVST
Additional services offered to potential VMMC clients	▶ None.	▶ IPC agents trained to offer demonstrate and assist men with use of HIVST kits if required. ▶ IPC agents recorded whether VMMC referees opted to take kit or not.	▶ IPC agents received basic training in the HCD-informed approach, including using the segmentation typing tool, to prioritise three key segments—enthusiasts, neophytes and embarrassed rejecters. ▶ Delivery of messages tailored to each 'segment'. ▶ IPC agents specifically required to address any pain-related concerns using a visual aid (pain-o-metre) to outline the VMMC procedure, healing process as well as possible pain management techniques. ▶ Training on appropriate targeted messaging and use of relevant tools.	▶ IPC agents received basic training in the HCD-informed approach, including using the segmentation typing tool, to prioritise three key segments - enthusiasts, neophytes and embarrassed rejecters. ▶ Delivery of messages tailored to each 'segment'. ▶ IPC agents specifically required to address any pain-related concerns using a visual aid (pain-o-metre) to outline the VMMC procedure, healing process, as well as possible pain management techniques. ▶ Training on appropriate targeted messaging and use of relevant tools. ▶ IPC agents trained to offer demonstrate and assist men with use of HIVST kits if required. ▶ IPC agents recorded whether VMMC referees opted to take kit or not.

HCD, human-centred design; HIVST, HIV self-testing; IPC, interpersonal communication agent; VMMC, voluntary medical male circumcision.

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Table 2 Overview of VMMC service-delivery models

VMMC service-delivery model	Static (fixed) (district hospital sites)	Integrated mobile health facility sites	Mobile outreach health facility sites
Specific characteristics	► Public sector trained clinicians	► Public sector trained clinicians	► Public sector trained clinicians
	► Public sector remuneration supplemented by programme incentives	► Public sector remuneration supplemented by programme incentives	► Public sector remuneration supplemented by programme incentives
	► VMMC provided at district health facilities on a continuous basis	► Trained clinicians from district hospitals deployed to existing health facilities intermittently	► VMMC offered through mobile clinic services when recruited numbers justified
	► VMMC offered to walk-in clients	► VMMC services provided on specific days	► VMMC offered at more remote health facility sites
		► Ongoing facility capacitation to eventually assume full VMMC site status including training of local staff and adequate equipment	► Temporary operating theatres set up for 1 day at a time

VMMC, voluntary medical male circumcision.

Participants, specifically drawn from a facility staff roster or list (all or every second participant if more than six), were asked for permission to be followed up all day over a maximum 3-day period in the course of VMMC service provision following voluntary informed consent. Time and motion observations were also used to capture client flow at peak and off-peak periods.

Cost data analysis

In order to estimate the full costs of all resources consumed in the demand creation programme and VMMC service-delivery, data from the PSI expenditure analysis were combined with that from the health facility data collection and analysed in a specifically designed Microsoft Excel spreadsheet.

Actual financial expenditures were analysed (line by line), categorised by input type and allocated to the respective VMMC demand creation model.[51 52] This top-down costing approach which ensures inefficiencies, down time and wastage are more fully accounted for, began with overall VMMC expenses for 18 districts, extraction of expenses for the five RCT districts and then stepwise allocation to respective cost centres.[51 61] Expenditure data included any transactions already incurred before the demand creation programme started. Demand creation expenses assessed were capital and start-up (development costs, initial IPC training, equipment) and recurrent costs (personnel, vehicle operation and maintenance, communication and education, HIVST kits, promotional supplies, training and meetings, consultancy/service fees and monitoring and evaluation (M&E)). Online supplemental file 2 provides more detailed definitions of the cost categories and study cost inputs.

A proportion of the value of office equipment for central, regional and district staff plus IPC tablets used to record programme M&E data was allocated based on staff level of effort dedicated to the programme. Cost allocation followed predefined allocation factors, based on project M&E data, including the proportion of IPC agents trained, proportion of active IPC agents, proportion of clients reached, proportion circumcised, proportion of distributed HIVST kits, proportion of information, education and communication material and distance from central office.[52 56] Online supplemental table A3 presents allocation factors applied to each input type.

In addition to the analysis of the PSI demand creation programme expenditures, we also used the microcosting exercise to estimate the costs of VMMC service-delivery at the health facility-level. We estimated both direct (consumables and non-consumable commodities, personnel salaries and reimbursement scheme costs as well as training costs) and indirect VMMC service costs (capital costs, waste management costs, support personnel costs and programme supervision costs at the district level). Each input required to provide VMMC services was quantified (microcosting) and valued. Shared overhead costs such as management, building space and equipment were allocated to clinic services based on recorded usage. Space was used to allocate security, reception, maintenance services and utilities costs.

We estimated total programme costs by adding up the costs of demand creation and service-delivery. We then proceeded to derive an average cost per client reached and circumcised by dividing the full total programme cost by the number of clients reached and circumcised. We assessed the relationship between unit cost and scale (number of

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clients circumcised) for the three VMMC service-delivery models. We also assessed changes in unit costs per client circumcised when combining demand creation and VMMC service-delivery costs and considering VMMC service-delivery characteristics such as type of facility, urbanicity, ownership (privately-run (church) vs public-sector run clinics) and size of facility in terms of annual number of clients served. All costs were analysed in 2018 US$.

Sensitivity analysis

We conducted one-way sensitivity analyses to assess the impact of key assumptions on the unit cost per client reached and circumcised. We varied the discount rate used to annualise costs between 0% and 15% to assess impact of zero discounting or using the Zimbabwe central bank discount rate (prevailing discount rates during the study period was 7%). We further evaluated the impact of decreasing or increasing (±10%) costs of training, commodities, personnel, other capital costs including programme and promotional equipment as well as communication and education (mobilisation). To assess impact of longer or shorter project duration, we varied annualisation (economic life years) time frames: VMMC programme start-up life between 3 and 7 years (base case is 5 years); training between 1 and 3years (base case is 4 years); furniture and equipment between 3 and 7 years (base case is 5 years); building economic life between 20 and 50 years (base case is 35 years); vehicle economic life between 5 and 15 years (base case is 10 years).

Patient and public involvement

Patients or members of the public were not involved in the design, or conduct, or reporting, or dissemination plans of the research.

RESULTS

Total costs and cost composition

Table 3 summarises the findings of the cost analysis. The total annual programme cost was $752 585 across the four demand creation approaches including service-delivery. The average cost per client reached with demand creation plus cost per circumcision were $58 and $174, respectively. Highest costs per client reached were in the HCD arm—$68 and lowest costs in standard demand creation ($52) and HIVST ($55) arms, respectively. The highest cost per client circumcised was observed in the arm where HIVST and HCD were combined ($226) and the lowest in HCD alone arm ($160).

Figure 1 presents the cost composition across each of the demand creation+VMMC service-delivery models. Demand creation recurrent costs account for more than half (57%) of the programme costs and VMMC service-delivery inputs (consumables and non-consumable commodities, personnel salaries and reimbursement scheme costs as well as training costs) for almost one third (34%). Capital and personnel costs represent 9% and 4% of the total cost, respectively. Panel B of figure 1 shows the composition of VMMC cost by the VMMC delivery model. Personnel costs account for 50%, 42% and 36% of total cost for static (fixed) model, outreach and integrated mobile model, respectively. Capital costs present the lowest relative weight across the three types of VMMC delivery. VMMC unit cost per circumcision was lowest in the static (fixed) service-delivery model ($54) and highest in the integrated service-delivery model ($63) (figure 2).

Figure 3 displays the relationship between unit cost and scale (number of clients circumcised) for the three VMMC service-delivery models. We observed a negative relationship between these variables for the three types of VMMC delivery consistent with economies of scale. In figure 4 (also see online supplemental table A1), we show changes in the total unit cost per client circumcised when combining demand creation and VMMC service-delivery costs by VMMC service-delivery characteristics (clinic or hospital, private or public and low or high volume). VMMC unit costs (combining demand creation and service-delivery) were lowest in rural high-volume privately run (church) clinics within the HIVST model ($86) and highest in rural low-volume public-sector run clinics within the standard mobilisation arm ($288). Within the SDM arm, unit costs ranged from $153 in rural high-volume privately run (church) hospitals to about $288 where circumcisions were performed in rural-low-volume public-sector run clinics, representing the arm with the highest unit cost when comparing all four demand creation approaches. The lowest unit costs were observed in the HCD+HIVST model ranging from $87 in rural high-volume privately-run (church) clinics to $141 in rural-low-volume-public sector run clinics.

Sensitivity analysis results

Online supplemental figures A1 and A2 display results of the sensitivity analysis for both clients reached and circumcised which remained robust when key cost parameters were varied. Unit costs were highly sensitive to programme annualisation (economic life years) time frames (for training and start-up) and increases or decreases in commodities and personnel costs. Varying VMMC programme training life between 2 and 6 years resulted in costs of $57.17 and $61.32 per client reached and $170.95 and $183.35 per client circumcised. Varying VMMC programme start-up life between 3 and 7 years resulted in costs of $57.76 and $59.26 per client reached and $172.71 and $177.19 per client circumcised. Varying commodities up and down 10% resulted in costs of $57.60 and $58.82 per client reached and $172.24 and $175.86 per client circumcised. Varying personnel up and down 10% resulted in costs of $57.74 and $58.68 per client reached and $172.65 and $175.45 per client circumcised.

DISCUSSION

This, to our knowledge, is one of the first studies to estimate economic costs of VMMC demand creation approaches incorporating HCD-informed approaches and HIVST to motivate men to take up VMMC. We

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Table 3 VMMC cost for a 6 months period, May–October 2018 (in 2018 US$)

	Total VMMC mobilisation programme		Standard demand creation		SDC + HIVST approach		HCD approach		HCD approach +HIVST	
Input type	**$**	**%**	**$**	**%**	**$**	**%**	**$**	**%**	**$**	**%**
Demand creation start-up costs	$21 918	3	$5646	2	$5313	4	$5479	3	$5479	4
PSI Demand Creation Capital Costs										
Development costs (SOC & HCD)	$41 045	5	$9071	4	$6687	5%	$12 643	6	$12 643	9
Initial IPC training	$1637	0	$422	0	$397	0	$409	0	$409	0
Equipment	$1680	0	$439	0	$405	0	$417	0	$417	0
Total demand creation capital costs	$44 360	6	$9932	4	$7489	5	$13 470	6	$13 470	9
PSI demand creation recurrent costs										
Personnel	$28 278	4	$8667	3	$6508	5	$6612	3	$6490	5
Vehicle operation and maintenance	$291 899	39	$116 039	45	$53 743	37	$74 181	36	$47 937	33
Communication and education	$53 637	7	$9667	4	$9667	7	$17 151	8	$17 151	12
HIVST kits	$2696	0		0	$1682	1		0	$1014	1
Promotional supplies	$23 392	3	$4216	2	$4216	3	$7480	4	$7480	5
Training and meetings	$10 776	1	$3284	1	$2523	2	$2454	1	$2515	2
Consultancy/service fees	$10 523	1	$3272	1	$2139	1	$2124	1	$2564	2
Other recurrent costs	$4661	1	$1846	1	$854	1	$1192	1	$770	1
M&E	$4725	1	$1650	1	$1125	1	$975	0	$975	1
Total demand creation recurrent costs	$430 587	57	$148 641	58	$82 457	57	$112 169	54	$86 896	61
Total demand creation costs	$496 864		$164 218		$95 260		$131 118		$105 845	
Direct VMMC service costs										
Commodities, consumables and non-consumables	$78 405		$28 564		$14 826		$23 489		$11 527	
Personnel costs—direct	$34 196		$12 458		$6466		$10 245		$5027	
Personnel costs—cost reimbursement scheme	$60 564		$22 064		$11 452		$18 144		$8904	
Training costs	$37 387		$13 620		$7069		$11 200		$5496	
Subtotal (direct VMMC costs)	$210 552	28		30		28		30		22
Indirect VMMC service costs										
Capital costs	$38 457		$14 010		$7272		$11 521		$5654	
Waste management costs	$2163		$788		$409		$648		$318	
Support personnel costs	$4387		$1598		$830		$1314		$645	

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Table 3 Continued

Input type	Total VMMC mobilisation programme $	%	Standard demand creation $	%	SDC + HIVST approach $	%	HCD approach $	%	HCD approach +HIVST $	%
Programme supervision costs	$161		$58		$30		$48		$24	
Subtotal (indirect VMMC costs)	$45 168	6	$16 455	6	$8541	6	$13 532	7%	$6641	5
Total VMMC service costs	$255 720		$93 161		$48 354		$76 610		$37 595	
Cost per client reached										
Total VMMC demand creation costs	$752 585	100	$257 379	100	$143 614	100%	$207 728	100	$143 440	100
Number reached	12 929		4937		2603		3062		2327	
Cost per client reached	$58		$52		$55		$68		$62	
Number circumcised	4324		1576		816		1296		636	
Cost per VMMC client (service-delivery+DC Costs)	$174		$163		$176		$160		$226	

Note that totals have been rounded to the nearest US$.
DC, demand creation; HCD, human-centred design; HIVST, HIV self-testing; VMMC, voluntary medical male circumcision.

estimated costs of each of the four models combining costs of demand creation and VMMC service-delivery. Demand creation and communication costs constituted 66% of programme costs compared with 34% for VMMC service-delivery. Vehicle running costs were the highest cost contributor (39%) ahead of staff costs (23%), communication and education (7%) and other indirect VMMC costs (6%). There was wide variation in unit costs across arms with highest costs per client reached and circumcised found in the HCD+HIVST arm and the lowest costs in the standard demand creation and HCD arms. Despite incurring similarly high demand creation activity-related costs, arms 1 (SOC) and 3 (HCD) had lower unit costs as they had a higher proportion of clients reached and circumcised.

For VMMC service-delivery, unit costs were lowest in the static (fixed) service-delivery model and highest in the integrated mobile service-delivery approach. Results show a negative relationship between unit cost and scale, findings consistent with the presence of economies of scale. Rural high-volume-private (church-run) clinics within the HIVST model had lowest unit costs whereas rural-low-volume-public-sector run clinics within the standard mobilisation arm had highest costs. Rural high-volume-privately (church) run clinics had lowest unit costs in the HCD+HIVST model.

Costs of this study are consistent with results from other VMMC studies in Zimbabwe and elsewhere in Southern Africa although differences in strategies and contexts may limit comparability. A similar study assessed costs of two models of demand creation and VMMC targeting school-going adolescents as part of the CAPRISA study in rural KwaZulu-Natal in South Africa and found a cost of $127.68 per circumcision for 4987 young men circumcised although VMMC service-delivery costs accounted for 58% of the total cost, compared with 32% for demand creation activities.[62] An earlier economic evaluation of locally tailored demand creation activities (including mass media, community mobilisation and targeted service-delivery) in increasing uptake of campaign-delivered VMMC among men aged 20–34 years in Tanzania found costs per VMMC in the intervention arms were $62 in Tabora and $130 in Njombe, and in the control arms $70 and $191, respectively.[43]

Key strengths of this analysis include the use of combined expenditure analysis and facility microcosting, a strategy which ensures all relevant costs are captured to the greatest extent possible including any investments not fully used.[43 50–52] Our study also assessed costs of VMMC demand creation across three VMMC service-delivery modalities and employed an intensive 3-day time and motion analysis at each facility to assess staff time allocation.[59 60] This minimised the need to rely on staff interviews, which are often subject to recall bias. Recall bias would have possibly led to overestimation or underestimation of time spent on VMMC service-delivery versus other integrated services. A further strength of this economic evaluation lies in the inclusion of demand

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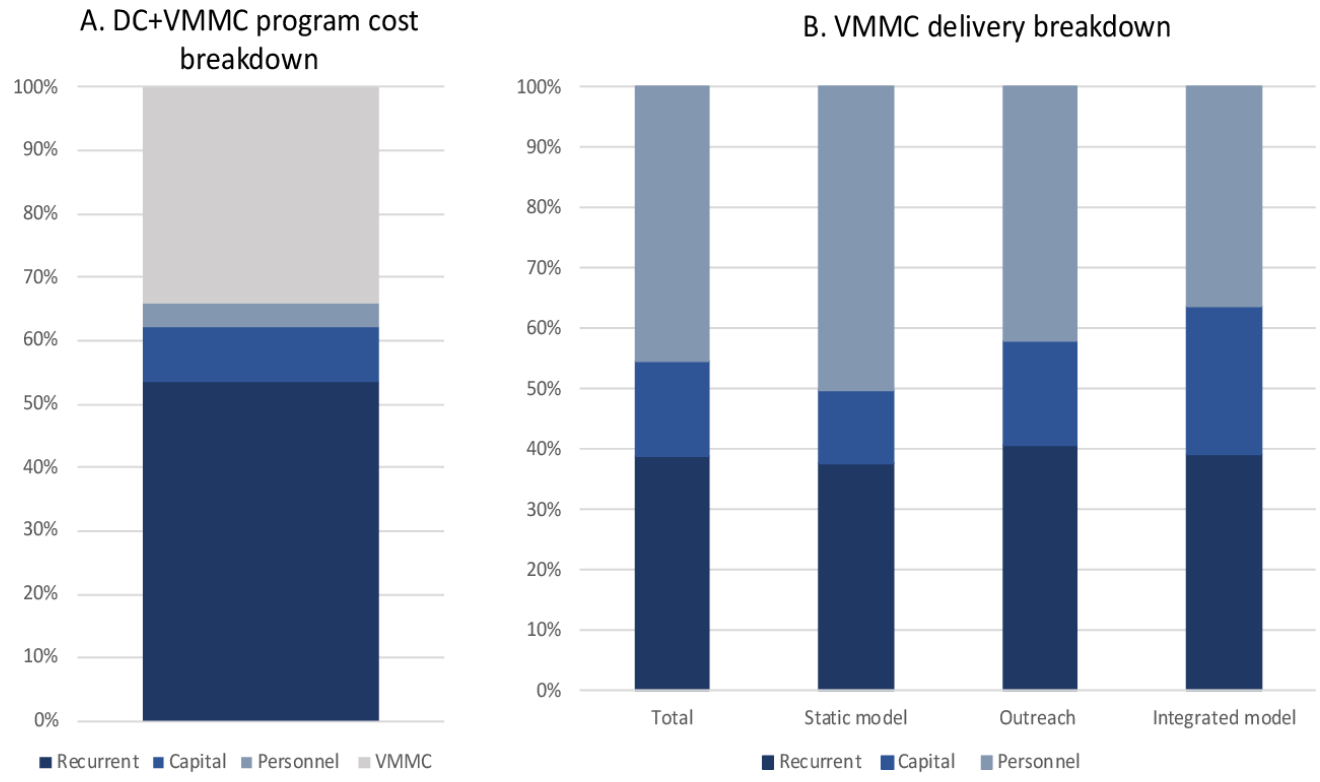

* DC - Demand creation

Figure 1 DC+VMMC programme cost and VMMC delivery cost breakdown. VMMC, voluntary medical male circumcision.

creation costs, which have largely been excluded in previous economic analyses of VMMC service provision.[43]

The cost estimates used in this study may be subject to a number of limitations. The cost analysis was performed in the context of a RCT and in a non-governmental organisation implementer setup. The analysis may therefore not reflect scale-up within a public sector model. As outlined in the methods section, unit cost estimates were also borne out of both expenditure analysis and activity-based costing. Although these two approaches combined can help us achieve the best cost estimates by minimising exclusion of cost inputs such as overheads and donated goods, inaccuracies may also arise out of the choice of allocation factors used to assign costs. This analysis, however, remains important as it helps cover an important gap in the literature on VMMC demand creation and service provision economic costs. The study also adds to a small but growing literature presenting disaggregated costs of VMMC demand creation and service-delivery.

In conclusion, there was high variability in unit costs across arms and sites. Highest costs per client circumcised were observed in the HCD+HIVST arm and within an integrated service-delivery setting. Lowest costs per client circumcised were seen in the HCD arm followed

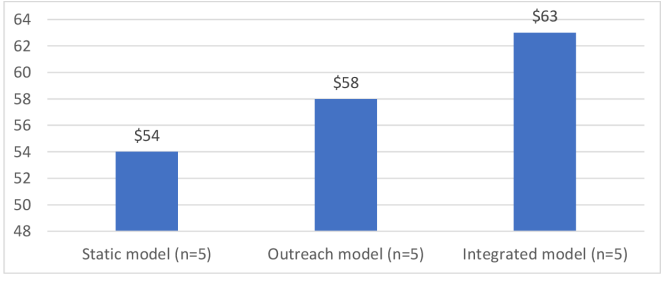

Figure 2 VMMC unit cost by type of service-delivery model. VMMC, voluntary medical male circumcision.

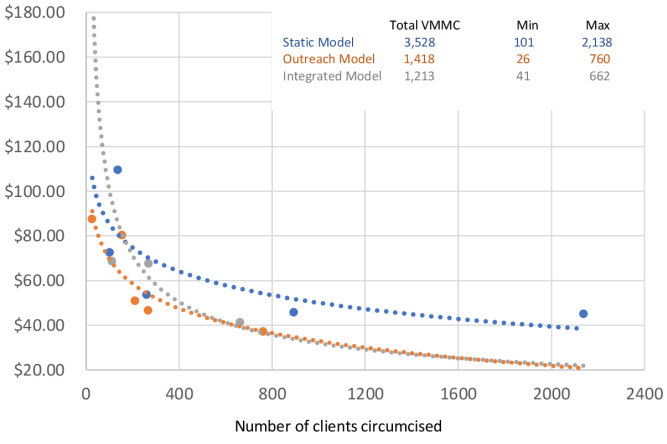

Figure 3 VMMC unit cost and scale across models of service-delivery. VMMC, voluntary medical male circumcision.

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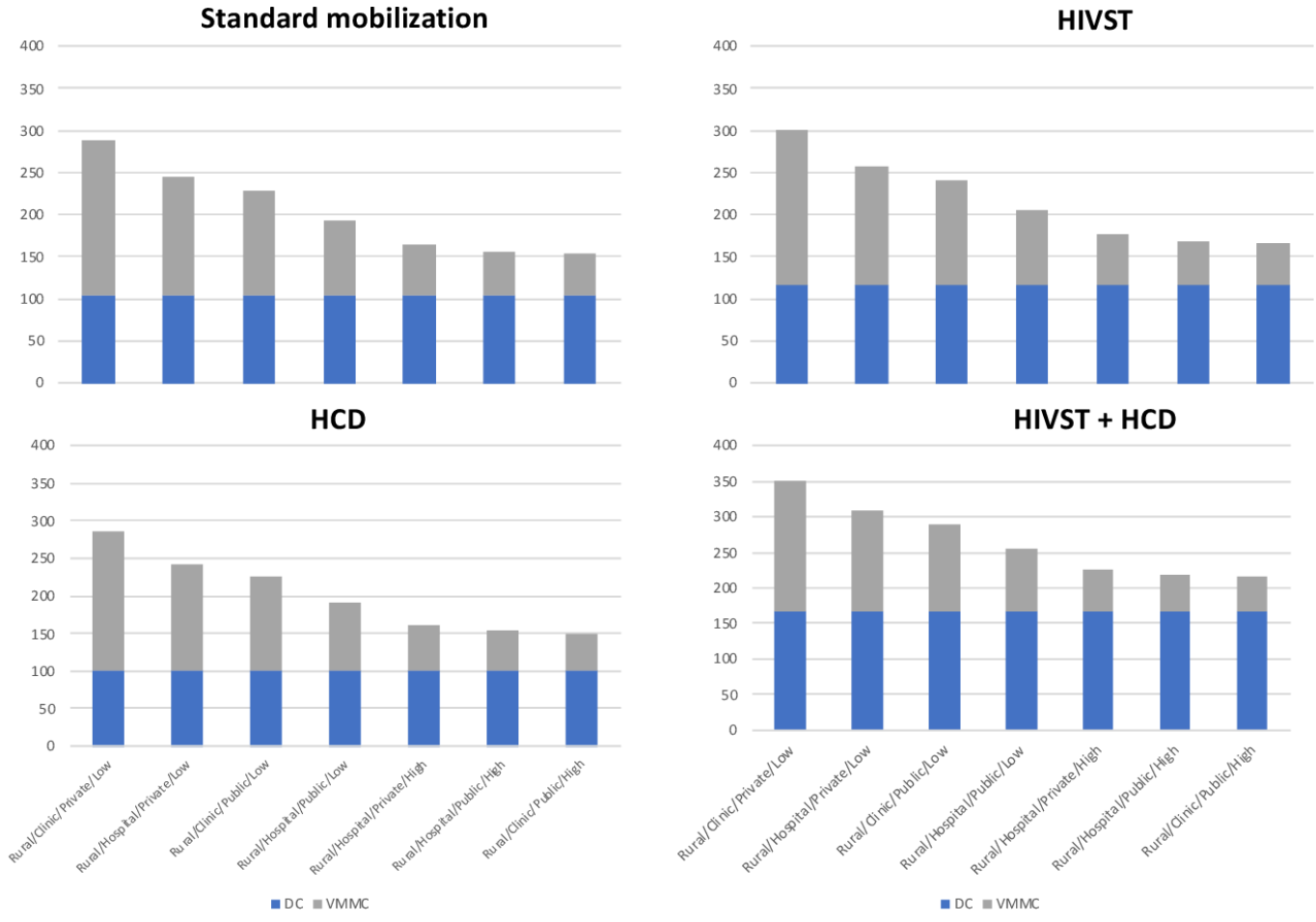

* DC – Demand creation

Figure 4 Combined unit cost of demand creation and VMMC service-delivery. HCD, human-centred design; HIVST, HIV self-testing; VMMC, voluntary medical male circumcision.

by SDC. This cost variation suggests that efficiency gains could be made in VMMC service-delivery across various platforms. This is evident in the lower costs exhibited in rural high-volume public sector clinics compared with rural low-volume private (church-run) clinics. The negative relationship between unit cost and numbers circumcised suggest economies of scale highlighting the need for intensified demand creation activities to optimise uptake of VMMC and achieve optimal utilisation of inputs. Based on the findings of this study, the SDC and HCD arms provide greater scope for efficiency by spreading costs on higher numbers of clients reached and circumcised. Mobilisation programmes that intensively target higher conversion rates are therefore needed in-order to achieve cost efficiencies.

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Contributors CM, WM, KH, AP, FMC and SBA conceived and designed the costing study protocol. CM, CG, PC, SC and PM collected data. GN, SX, OM, NT and NM facilitated the collection of data. CM, WM, DCG, CG, PC, SC, PM, KLF, FTP, FMC and SBA carried out data analysis and interpreted the data with involvement from GN, SX, OM, NT, NM, CJ, KH. CM, WM, DCG, FMC and SBA drafted the manuscript and all authors revised it critically. All authors have approved the final manuscript.

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Data availability statement Data are available on request. These are financial and economic cost data used to assess efficiency of models of VMMC demand creation and service delivery. They also include deidentified patient data in the form of time and motion observations.

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