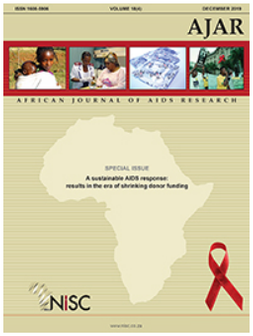

African Journal of AIDS Research

ISSN: 1608-5906 (Print) 1727-9445 (Online) Journal homepage: https://www.tandfonline.com/loi/raar20

Meta-analysis of average costs of HIV testing and counselling and voluntary medical male circumcision across thirteen countries

Carlos Pineda-Antunez, Gisela Martinez-Silva, Diego Cerecero-Garcia, Lily Alexander, Drew B Cameron, Chris Chiwevu, Lalit Dandona, Carol Dayo Obure, Steven Forsythe, Van Thu Nguyen, Stella Settumba, Michel Tchuenche, Hoang Van Minh, James G Kahn, Gabriela Gomez, Sedona Sweeney, Anna Vassall, Lori Bollinger, Carol Levin & Sergio Bautista-Arredondo

To cite this article: Carlos Pineda-Antunez, Gisela Martinez-Silva, Diego Cerecero-Garcia, Lily Alexander, Drew B Cameron, Chris Chiwevu, Lalit Dandona, Carol Dayo Obure, Steven Forsythe, Van Thu Nguyen, Stella Settumba, Michel Tchuenche, Hoang Van Minh, James G Kahn, Gabriela Gomez, Sedona Sweeney, Anna Vassall, Lori Bollinger, Carol Levin & Sergio Bautista-Arredondo (2019) Meta-analysis of average costs of HIV testing and counselling and voluntary medical male circumcision across thirteen countries, African Journal of AIDS Research, 18:4, 341-349, DOI: 10.2989/16085906.2019.1679850

To link to this article: https://doi.org/10.2989/16085906.2019.1679850

African Journal of AIDS Research 2019, 18(4): 341–349

AJAR
ISSN 1608-5906 EISSN 1727-9445
https://doi.org/10.2989/16085906.2019.1679850

Research Article

Meta-analysis of average costs of HIV testing and counselling and voluntary medical male circumcision across thirteen countries

Carlos Pineda-Antunez[1], Gisela Martinez-Silva[1], Diego Cerecero-Garcia[1], Lily Alexander[2], Drew B Cameron[3], Chris Chiwevu[9], Lalit Dandona[5], Carol Dayo Obure[11], Steven Forsythe[4], Van Thu Nguyen[6], Stella Settumba[7], Michel Tchuenche[8], Hoang Van Minh[9], James G Kahn[10], Gabriela Gomez[11], Sedona Sweeney[11], Anna Vassall[11], Lori Bollinger[4], Carol Levin[2] and Sergio Bautista-Arredondo[1]*

[1]Center for Health Systems Research, National Institute of Public Health, Cuernavaca, Mexico
[2]Department of Global Health, University of Washington, Seattle, USA
[3]Health Policy and Management, University of California Berkeley, Berkeley, USA
[4]Avenir Health, Glastonbury CT, USA
[5]Public Health Foundation of India, Gurugram, National Capital Region, India
[6]FHI 360, Hanoi, Vietnam
[7]The Kirby Institute, University of New South Wales, Sydney, Australia
[8]Independent consultant
[9]Center for Population Health Sciences, Hanoi University of Public Health, Hanoi, Vietnam
[10]Philip R. Lee Institute for Health Policy Studies, University of California San Francisco, California, USA
[11]Department of Global Health and Development, London School of Hygiene and Tropical Medicine, London, UK
**Corresponding author email: sbautista@insp.mx*

Objective: **Explore facility-level average costs per client of HIV testing and counselling (HTC) and voluntary medical male circumcision (VMMC) services in 13 countries.**
Methods: **Through a literature search we identified studies that reported facility-level costs of HTC or VMMC programmes. We requested the primary data from authors and standardised the disparate data sources to make them comparable. We then conducted descriptive statistics and a meta-analysis to assess the cost variation among facilities. All costs were converted to 2017 US dollars ($).**
Results: **We gathered data from 14 studies across 13 countries and 772 facilities (552 HTC, 220 VMMC). The weighted average unit cost per client served was $15 (95% CI 12, 18) for HTC and $59 (95% CI 45, 74) for VMMC. On average, 38% of the mean unit cost for HTC corresponded to recurrent costs, 56% to personnel costs, and 6% to capital costs. For VMMC, 41% of the average unit cost corresponded to recurrent costs, 55% to personnel costs, and 4% to capital costs. We observed unit cost variation within and between countries, and lower costs in higher scale categories in all interventions.**

Keywords: efficiency, unit cost, prevention, cost variation

Introduction

Although preventative interventions have been integral in reducing the number of new HIV infections, this progress has slowed in the past ten years (UNAIDS, 2016). Prevention programs such as HIV testing and counselling (HTC) and voluntary medical male circumcision (VMMC) have been squeezed by declining funding levels, despite their documented effectiveness to continue the progress toward reducing HIV infections (AVERT, 2018).

Within this context of declining funding, tracking empirical cost data is even more imperative to efficiently allocate resources, make cost projections, and identify inefficiencies (Bautista-Arredondo et al., 2018). Previous studies have shown that key determinants of cost variations within HIV preventative services occur at the facility level (Bautista-Arredondo, Gadsden, Harris, & Bertozzi, 2008; Galárraga et al., 2017; Mwenge et al., 2017), and therefore tracking costs at the service delivery level is vital. However, many previous unit cost studies include few observations, often focusing on a single facility. The multi-facility costing studies that do exist have primarily been conducted within one country, thus making it challenging to explore variations that are consistent across countries (Larson, Tindikahwa, Mwidu, Kibuuka, &

Magala, 2015; Marseille, Kahn, Beatty, Jared, & Perchal, 2014; Menon et al., 2014; Tchuenche et al., 2018, 2016) Few studies have measured VMMC and HTC unit costs across relatively large samples that consider several service delivery characteristics (Bollinger et al., 2014; Marseille et al., 2014).

The goal of the Global Health Cost Consortium (GHCC), a Bill and Melinda Gates Foundation-funded initiative, is to address this gap by improving the availability, quality, timing, and policy-relevance of cost information. We coordinated the obtainment, aggregation, and analysis of primary costing data from existing published research papers or reports to estimate more accurate costs of HIV services, thereby informing the development of more effective global health programs and policies (Vassall et al., 2017). Our study leverages previously published unit cost primary data on HTC and VMMC interventions in 14 studies across 13 countries.

Methods

Overview

We first identified relevant HTC and VMMC studies through a systematic literature review and excluded studies with non-modelled and non-facility-level costs. We contacted authors of the studies to request the facility-level data underlying their results. We then aggregated and standardised the primary data obtained and estimated average unit costs across different combinations of service delivery platform characteristics. Finally, applying a meta-analysis, we produced a weighted average unit cost for HTC and VMMC.

Definition of unit costs

To measure unit costs for HTC and VMMC, we disaggregated costs into three broad input cost categories – capital, recurrent, and personnel. We grouped equipment and vehicles into capital costs. Recurrent costs included consumables, such as test and disposable circumcision kits, maintenance expenses and utilities, and training. Personnel costs consist of salaries of direct medical staff (physicians and nurses) and non-medical staff (managers, supervisors, and ancillaries). The sum of capital, recurrent, and personnel annual costs yielded the total costs for each facility. The outputs included the number of yearly counselling and testing visits for HTC and the number of male circumcisions for VMMC. Finally, the unit cost was the facility-level average annual cost per output, i.e. the yearly total cost divided by the total outputs from each intervention in each facility in the same year.

Data obtainment

Our data collection began with a systematic review of published and grey literature on HIV/AIDS costs. We searched scholarly databases (PubMed, Embase, Web of Science, Cochrane Central Register of Controlled Trials, Cochrane Reviews, NHS Economic Evaluations Database, and LILACS), grey literature sources, previously aggregated unit cost searches, including Avenir's Unit Cost Repository (https://www.avenirhealth.org), and then performed snowball sampling from selected studies.

The literature search identified 54 distinct HIV interventions – including prevention, treatment and care, testing, enablers, and health systems – published between January 2006 and July 2018 in 11 717 papers. After screening out studies conducted in high-income country settings or those that included modelled costs, 203 articles remained. Of these, 31 papers reported HTC cost data, and 29 contained VMMC cost data. Full details of the search and screening protocol can be found in De Cormier et al. (2019) in this special issue.

After reviewing the 60 studies to ensure that the cost data was original, non-modelled, and collected at the facility level, we identified 17 studies for HTC and 15 for VMMC as eligible for contacting the authors to request the data. From these 32 studies, we obtained primary data for 14 (43%) studies (7 for HTC and 7 for VMMC). For the eligible papers for which we did not obtain data (10 for HTC and 8 for VMMC), we extracted information about the country, the number of facilities and unit costs reported to compare them to those estimated with our analytic sample. We then standardised the aggregated primary data according to a multi-step process, described below; note that we included only results using the provider perspective.

Standardisation

Several steps were followed to standardise the data. First, we transformed costs reported in local currency to US dollars (hereafter $) using the local average exchange rate for the year of data collection (World Bank, 2019b), and inflated them to 2017 USD values using the US GDP price deflator (World Development Indicators database (World Bank, 2019a). All costs were standardised to represent one year of activities.

Second, we recategorised author-reported variables into common cost categories across studies (see Table 1 for definitions). We conducted a web search based on the facility name to fill-in missing information on facility type and urbanicity where needed. If urbanicity was unknown after this step, we used demographic data of the area to categorise them as rural (<1000 person/km^2) or urban (>1000 person/km^2).

Third, based on the principles and methods of the GHCC Reference Case for Estimating the Costs of Global Health Services and Interventions (Vassall et al., 2018), we allocated input costs according to three broad categories – capital, recurrent, and personnel costs. Not all studies contained identical inputs, but all studies reported costs for the three broad categories. We did not input cost data in any case. We removed the cost categories that were present in only one study (training and supervision).

Service delivery platforms

Once the data was standardised, we estimated unit costs across both interventions and for all the facilities in the sample. Our dataset includes various site-specific characteristics, including scale, facility type, ownership, urbanicity, income level, and service modality.

Scale is defined as the total annual number of outputs per intervention – i.e. circumcisions or people tested. Facility type indicates if the facility is a clinic or hospital. Facility ownership distinguishes between public clinics and private/NGO facilities. Urbanicity designates a facility as urban or rural based on its location. We defined the country income level consistent with the World Bank categorisation (World

Bank, 2019c). Service modality variable was included only for HTC to distinguish between voluntary testing/counselling and provider-initiated testing/counselling (Table 1).

Descriptive analysis of unit costs

We conducted a descriptive analysis to explore the unit cost variation across scale, facility type, ownership, urbanicity, and country. The scale was categorised into three levels according to observed terciles of the number of outputs within each country: small (lowest tercile), medium (second tercile), and large scale (highest tercile). We also explored the unit costs composition by input category (personnel, recurrent, and capital) according to their average percentage with respect to the total cost.

Meta-analysis of cost data

We conducted a meta-analysis using the *metan* command in Stata statistical software version 15 (StataCorp, 2017) to estimate unit cost averages while accounting for random effects (Bower et al., 2003). We opted for random effect analysis since it has been previously documented that costs vary by implementation characteristics (Bautista-Arredondo et al., 2018). This meta-analysis method gives more weight to studies with a larger number of facilities due to the lower sampling variability, a process known as inverse variance weighting (Bower et al., 2003). A test for heterogeneity was also conducted to validate that random effects are preferable to a fixed effects model.

Results

We collected data from 772 facilities – 552 for HTC and 220 for VMMC – across 14 studies. Table 2 shows the descriptive statistics of the primary data collected. The proportion of urban and rural facilities was similar in both interventions. Publicly financed facilities represented 82% of the HTC facilities and 64% of the VMMC facilities. Clinics represented almost half of the 56% of HTC facilities and VMMC facilities. The mean cost per client served was $20 for HTC facilities and $66 for VMMC facilities, while the median cost per client

Table 1: Description of standardised variables

Variable	Description
Facility type	A binary variable that indicates if the facility is a clinic (reference) or hospital
Facility provider	A binary variable that distinguishes between the type of ownership, public (reference) or private/NGO
Urbanicity	A binary variable for the area where the facility was located, urban (reference) or rural
Total cost	The total cost of intervention
Unit cost	The total cost of the intervention divided by the number of outputs in each step of the attention cascade
Recurrent costs	The total recurrent cost (sum of all: medical supplies, laboratory tests, consultations)
Capital costs	The total capital cost (sum of all: administrative equipment, furnishings, laboratory equipment, medical equipment, vehicles)
Personnel costs	The total annual personnel salaries (sum of all: physicians, nurses, others)
Modality	Voluntary (reference) versus provided initiated program (for HTC only)
Level income	Level income of country
Scale	The number of yearly counseling and testing visits for HTC and the number of male circumcisions for VMMC

Table 2: Data obtained

	HTC		VMMC	
Observations by step	Testing: 552		VMMC: 220	
Observations by study	Dandona et al	6%	Bautista et al	43%
	Minh et al	4%	Bollinger et al	25%
	Obure et al (PITC)	13%	Chiwevu et al	4%
	Obure et al (VCT)	12%	Forsythe et al	3%
	Bautista et al	57%	Kripke et al	2%
	Settumba et al	2%	Menon et al	18%
	Nguyen et al	6%	Tchuenche et al	15%
	Adiatma et al	1%		
Urbanicity				
Rural facilities		49%		50%
Urban facilities		51%		50%
Ownership				
Private facilities		18%		36%
Public facilities		82%		64%
Facility type				
Hospitals		44%		47%
Clinics		56%		53%
Unit cost	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
Unit cost per client (USD)	20 (36)	9 (17)	66 (59)	45 (64)
HIV positive rate	12%	n/a		
Number of studies	7	7		
Countries	10	8		

served was $9 for HTC and $45 for VMMC, indicating that the unit cost distributions are skewed to the right.

In Table 3, we display the HTC and VMMC average unit costs by country and service delivery characteristics. Facilities in upper-middle-income countries showed the highest unit cost in both interventions ($33 for HTC and $123 for VMMC). Hospitals showed higher unit costs than clinics ($24 vs $18 for HTC, $74 vs $59 for VMMC). Privately financed facilities, when compared to their public counterparts, had higher costs in the case of HTC ($21 vs $17). For VMMC, this relationship was inverse ($64 vs $70). Regarding scale, we observed that as the number of clients served in a year increased, the unit cost decreased. For HTC, the average unit cost was 58% lower in medium scale facilities compared to small scale facilities, and 72% lower in large scale facilities compared to small scale facilities. For VMMC, the average unit cost was 23% lower in medium scale facilities compared to small scale facilities, and 34% when comparing large scale facilities to small scale facilities.

We observed variation in unit cost estimations across studies. Figure 1 shows the weighted unit cost estimates from the meta-analysis. The top panel displays unit cost estimates organised by study for HTC and VMMC, while the bottom panel display unit cost estimates organised by country. Note that both panels display the (identical) overall weighted unit cost at the bottom of the panel.

The overall weighted average unit cost per client served was $15 (95% CI $12, $18) for HTC and $59 (95% CI $45, $74) for VMMC. The I-squared coefficient for both interventions was higher than 95%, suggesting that unit cost variation depends on other factors besides measurement error. Only four studies reported costs for more than one country. Within-study variation in unit costs (Figure 1 top panel) therefore reflect differences in costs across countries identified using consistent measurement and analytic methods. We also present the weighted average of unit cost by country (Figure 1 bottom panel). In this case, the within-country variation in unit costs most likely reflects differences in costing approaches across studies. The advantage of our approach is evident for example in the case of Kenya and Eswatini for HTC, or Kenya and South Africa for VMMC, in which we produce more accurate estimates of unit costs by adding data from multiple sources on the same country estimate. Regarding HTC and VMMC unit costs by country, we show two 95% confidence intervals; the narrower represented by a rhombus indicating the variability within countries ($12–18 for HTC and $45–74 for VMMC), the broader represented by lines indicating the variability between countries ($4–26 for HTC and $4–115 for VMMC).

Next, we stratified the sample by both study and country to explore variation in unit cost composition (Figure 2). Recurrent and personnel costs explained a large proportion of the unit cost for both HTC and VMMC. On average, for HTC, recurrent costs made up 38% of the unit cost, personnel costs made up 56%, and capital costs 6%. For VMMC, 41% of the unit cost corresponded to recurrent cost, 55% for personnel cost, and 4% for capital cost.

In Figure 3, we show the variation in unit costs by both study and country, while in Figure 4, we show the unit cost variation by country only in the full sample (i.e. combining observations across studies for specific countries). We observed variation within and between countries. For HTC, the countries with the largest variation included: Nigeria ($1.7–551, IQR = 37), Indonesia ($42–72, IQR = 32), South Africa ($6.7–104, IQR = 25), and Vietnam ($3.3–116, IQR = 36). In the case of VMMC, South Africa and Namibia showed the largest variation, with cost ranges between $31 and $364 (IQR = 74) in South Africa, and between $66 and $121 (IQR = 37) in Namibia.

Discussion

In this article, we used facility–level primary data to create a pooled dataset with unit costs and facility characteristics for 13 countries and two HIV prevention interventions. By creating a multi-country database, we sought to emulate a study with a larger sample in terms of the number of facilities, countries, and implementation characteristics, to obtain more robust unit cost estimations for HTC and VMMC. Although we collected the same number of studies for both interventions, we obtained twice the number of facilities for HTC as for VMMC (552 vs 220). This is

Table 3: Unit cost of HTC and VMMC by facility characteristics, country income level and level of scale

	HTC			VMMC		
	Mean	Median	SD	Mean	Median	SD
Income level						
Low	5	3	5	42	28	42
Low-middle	21	9	39	43	37	41
Upper-middle	33	23	25	123	114	57
Facility characteristics						
Clinic	18	8	37	59	40	54
Hospital	24	10	35	74	49	64
Urban	20	9	29	66	47	58
Rural	21	9	43	66	42	61
Public	21	9	38	64	41	62
Private	17	9	27	70	48	54
Level of scale						
Low	35	15	56	78	53	69
Middle	15	9	16	60	41	51
Large	10	6	13	59	35	54

reflected in the more accurate estimates obtained for HTC ($15 SE: 1.52) than VMMC ($59 SE: 28.45).

The studies most commonly reported characteristics such as urbanicity, ownership, type of facility and scale. We explored the variability across these characteristics and found them to be influential sources of variation in the unit costs for both interventions. The relationship between unit costs and these characteristics was consistent across studies and countries, despite differences in study methodologies. These results offer important information to inform decision-makers as they consider allocation of resources.

Our work summarises several studies on the costs of VMMC and HTC for the first time and is unique due to the large number of facilities included in the estimations.

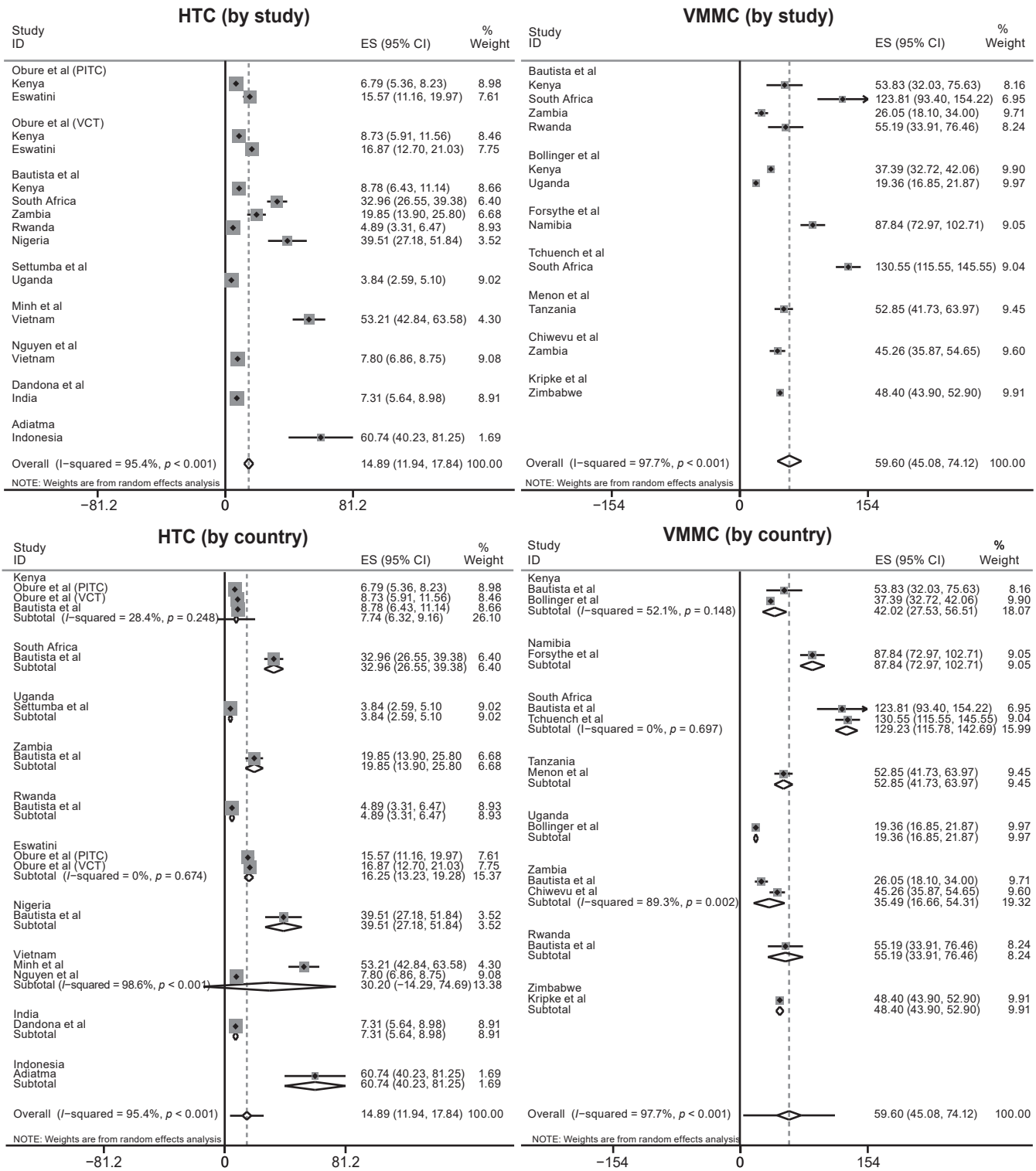

Figure 1: Forest plot of unit cost for HTC and VMMC

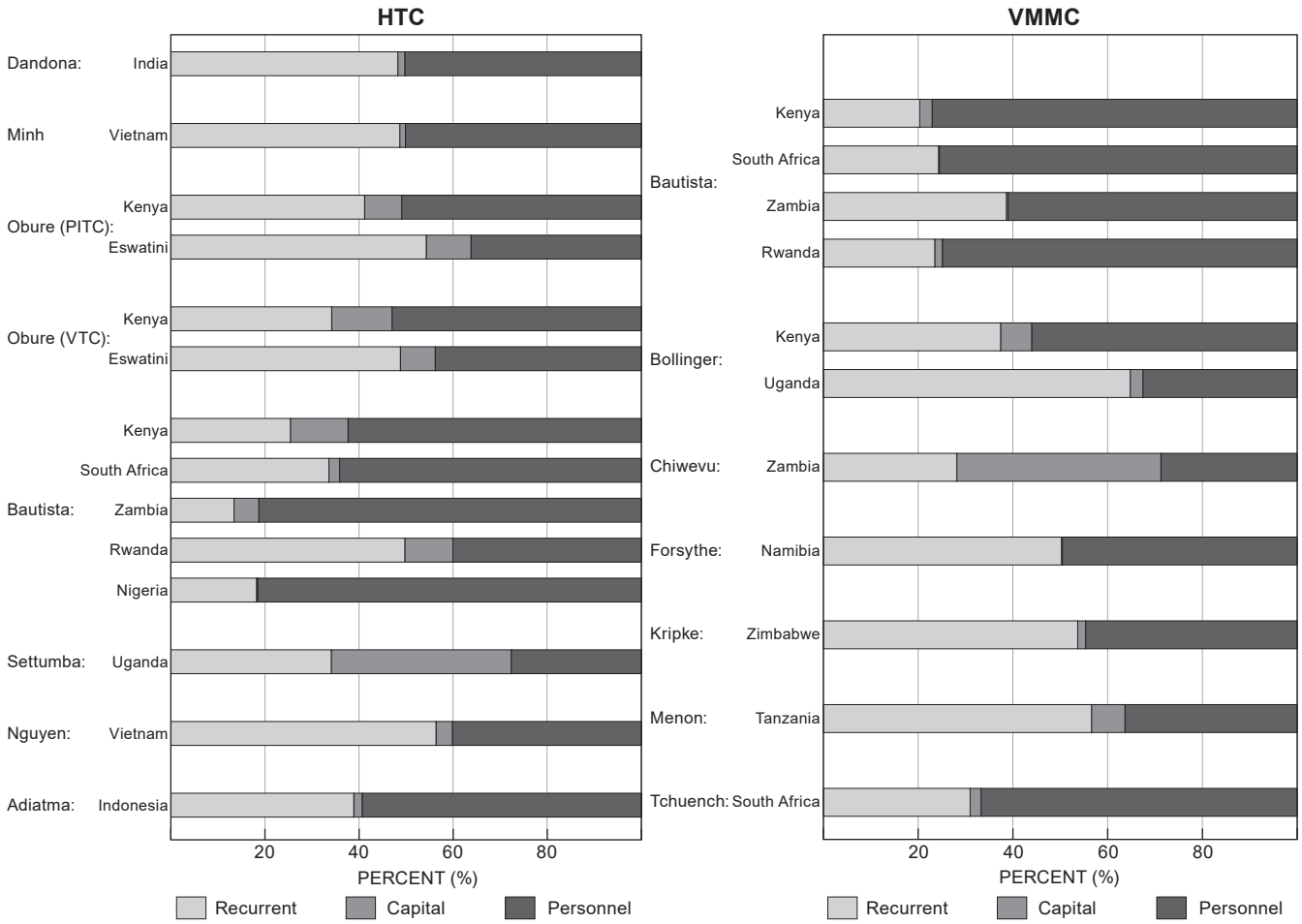

Figure 2: Breakdown of unit cost

Previous meta-analyses (Elia et al., 2016; Kim & Basu, 2016) have used aggregated values as reported in the publications, which masks potential variability across facilities. Another problem with that approach is that, in some cases, the cost reported in a study represents only one facility, while in others it represents an average across facilities. This creates an implicitly unbalanced dataset with potential biases. Our approach, which relies on primary data instead of aggregated estimates only, improves over the previous meta-analysis by weighting the study-country-level estimates by their standard error. The result is a weighted average unit cost, with higher weight given to estimates from larger samples. As a result, our analysis presents more precise cost estimates on HTC and VMMC than previous cost analyses. Given the importance of this type of data, it might be useful to replicate this type of analysis and update results as more data becomes available.

Our results showed that the average unit cost per client served was $15 (95% CI $12, $18) and USD $59 (95% CI $45, $74) for HTC and VMMC respectively. We also identified substantial cost variation between studies, as well as between and within countries. We also explored the unit cost composition for both interventions and found that recurrent and personnel costs represented the most substantial proportion of the average unit cost.

Among the eligible papers from which we did not obtain data, the average cost per person tested ranged from $8 up to $69 with a mean of $24, (37% higher than our average estimated cost per client tested). The total number of facilities in the sample not obtained was of 338 facilities (representing 61% of our analytic sample, $n = 552$) from eight countries which would add data on four countries not included in our sample (Malawi, Namibia, Madagascar, and Ukraine). Regarding VMMC, we did not obtain data from 8 studies that included 52 facilities (23% of our sample). The unit costs reported in these studies range from $24 to $143 with an average of $63, which is 6% higher than our estimated mean. These data provide results for two countries (Lesotho and Eswatini) not included in our sample.

There were several limitations to our work. First, although we aimed to reduce bias by standardising across study definitions and cost categories, we were unable to control for study design and measurement methods. Second, the costs used in this analysis did not include above-facility costs, therefore using these data to estimate total costs would underestimate substantially. We also had an unbalanced sample of facilities included in each study. We addressed this limitation by estimating an average unit cost with a meta-analysis, which weights the costs based on their standard error. Finally, most studies included ad hoc samples

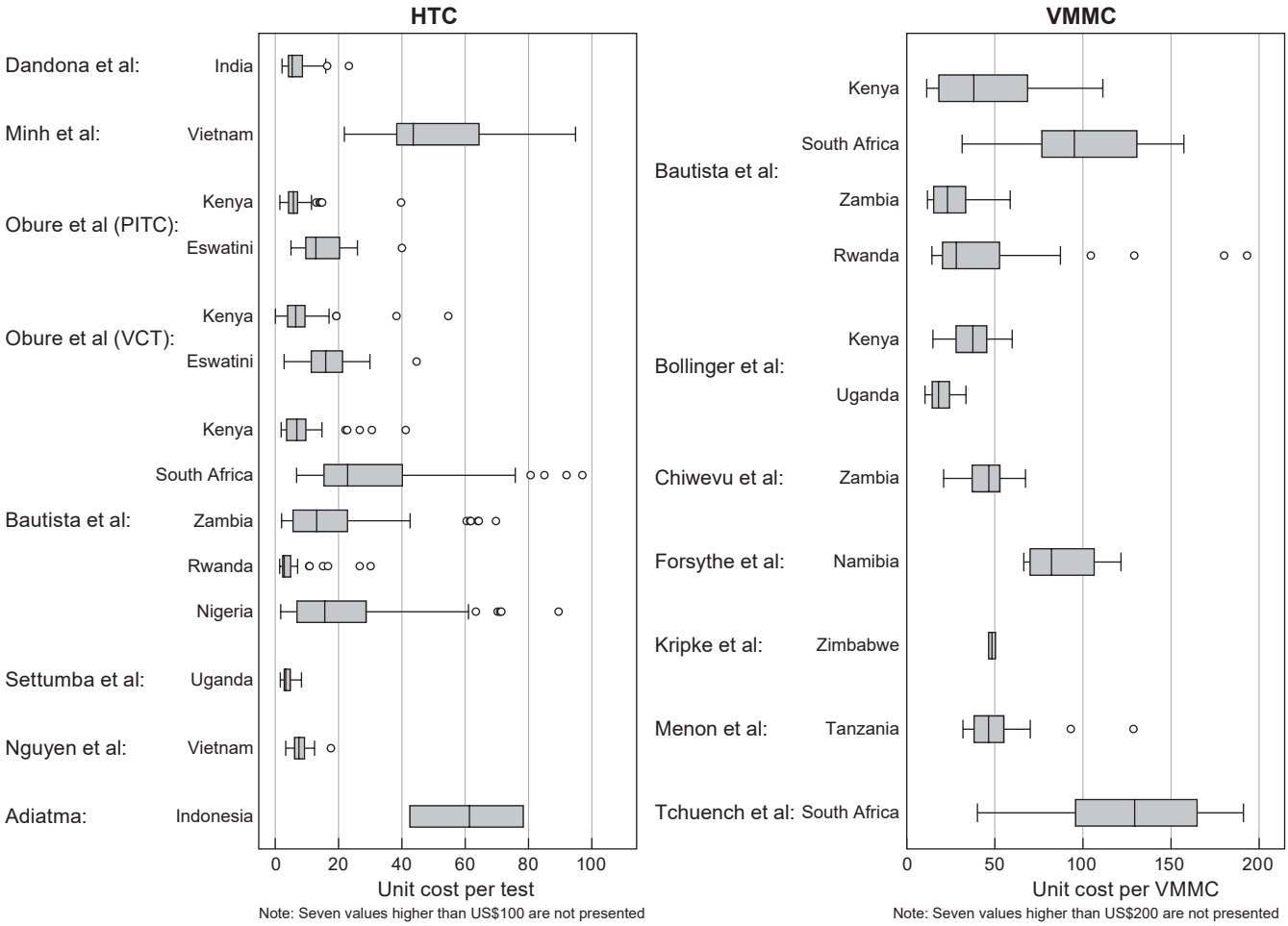

Figure 3: Unit cost variation by study

of facilities, meaning that we could not determine whether they were representative of most facilities in each country.

Conclusion

To our knowledge, this is one of the most comprehensive facility-level analyses of VMMC and HTC unit costs to date. Our study fills a gap in the costing literature through harnessing our large and diverse sample, which enabled us to estimate average unit costs and explore variation across a wide variety of context and service delivery characteristics. Our approach not only provides additional information for VMMC and HTC interventions, but could also serve as a guide on how to estimate unit costs using heterogeneous sources for overcoming sample size limitations in economic analyses.

Cost-effective interventions to prevent HIV are essential in maximising impact in a context of limited resources. Furthermore, funders, policy-makers, and decision-makers all need more accurate data cost data to plan resource allocation and program scale-up and our research has a strong potential to inform them in their budget planning to create and scale-up new HIV prevention programs.

Acknowledgements — We are grateful to our colleagues of the GHCC who made this work possible through their work on the design of the consortium's reference case, the systematic literature review, and the overall objectives and approach of the GHCC: Ben Herzel, Edina Sinanovic, Elliot Marseille, Lauren Carroll, Lucy Cunnama, Mariana Siapka, Mohamed Mustafa and Willyanne DeCormier Plosky. The GHCC project was funded by the Bill & Melinda Gates Foundation.

References

Avenir Health. (2010). *Unit Cost Database*. http://policytools.avenirhealth.org/UC/

Avert. (2018). HIV prevention programmes overview. Brighton, UK: Avert. https://www.avert.org/professionals/hiv-programming/prevention/overview

Bautista-Arredondo, S., Gadsden, P., Harris, J. E., & Bertozzi, S. M. (2008). Optimizing resource allocation for HIV/AIDS prevention programmes: An analytical framework. *AIDS (London, England), 22*(s1), s67–s74. https://doi.org/10.1097/01.aids.0000327625.69974.08

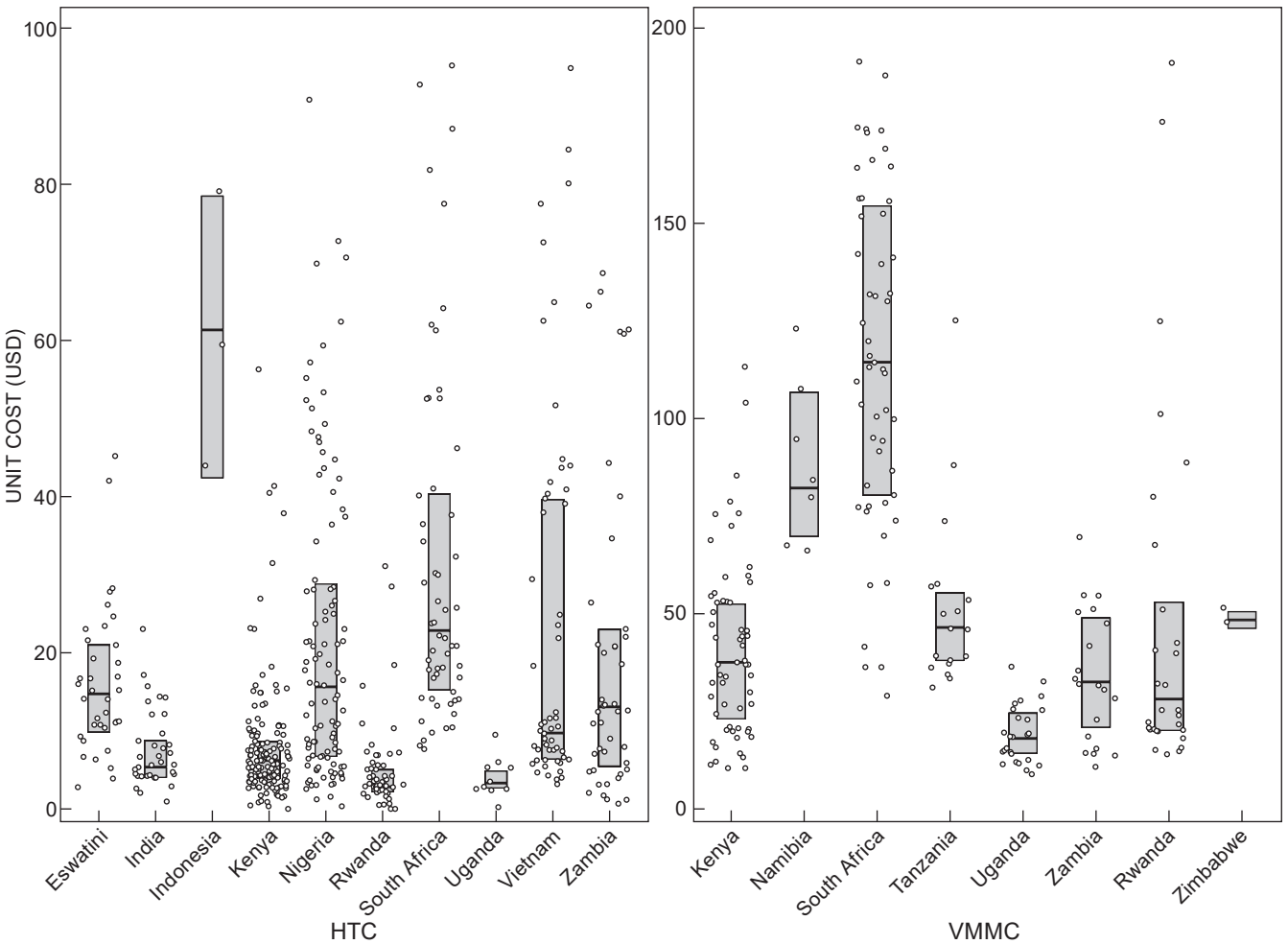

Figure 4: Unit cost variation by country

Bautista-Arredondo, S., Sosa-Rubi, S. G., Opuni, M., Contreras-Loya, D., La Hera-Fuentes, G., Kwan, A., … Wang'ombe, J. (2018). Influence of supply-side factors on voluntary medical male circumcision costs in Kenya, Rwanda, South Africa, and Zambia. *PLoS One, 13*(9), e0203121. https://doi.org/10.1371/journal.pone.0203121

Bollinger, L., Adesina, A., Forsythe, S., Godbole, R., Reuben, E., & Njeuhmeli, E. (2014). Cost drivers for voluntary medical male circumcision using primary source data from sub-Saharan Africa. *PLoS One, 9*(5), e84701. https://doi.org/10.1371/journal.pone.0084701

Bower, P., Byford, S., Barber, J., Beecham, J., Simpson, S., Friedli, K., … Harvey, I. (2003). Meta-analysis of data on costs from trials of counselling in primary care: Using individual patient data to overcome sample size limitations in economic analyses. *BMJ (Clinical Research Ed.), 326*(7401), 1247–1250. https://doi.org/10.1136/bmj.326.7401.1247

DeCormier Plosky, W., Bollinger, L., Alexander, L., Carroll, Cameron, D. B., Gomez, G. B… . & Kahn, J. G. (2019). Developing the unit cost study repository for HIV and TB costs: methodology and lessons learned. *African Journal of AIDS Research, 18(4).* https://doi.org/10.2989/16085906.2019.1680398.

Elia, M., Normand, C., Norman, K., & Laviano, A. (2016). A systematic review of the cost and cost effectiveness of using standard oral nutritional supplements in the hospital setting. *Clinical Nutrition, 35*(2)370–380. https://doi.org/10.1016/j.clnu.2015.05.010

Galárraga, O., Wamai, R. G., Sosa-Rubí, S. G., Mugo, M. G., Contreras-Loya, D., Bautista-Arredondo, S., … Wang'ombe, J. K. (2017). HIV prevention costs and their predictors: Evidence from the ORPHEA Project in Kenya. *Health Policy and Planning, 32*(10), 1407–1416. https://doi.org/10.1093/heapol/czx121

Kim, D. D., & Basu, A. (2016). Estimating the medical care costs of obesity in the United States: systematic review, meta-analysis, and empirical analysis. *Value in Health, 19*(5), 602–613. https://doi.org/10.1016/J.JVAL.2016.02.008

Larson, B., Tindikahwa, A., Mwidu, G., Kibuuka, H., & Magala, F. (2015). How much does it cost to improve access to voluntary medical male circumcision among high-risk, low-income communities in Uganda? *PLoS One, 10*(3), e0119484. https://doi.org/10.1371/journal.pone.0119484

Marseille, E., Kahn, J. G., Beatty, S., Jared, M., & Perchal, P. (2014). Adult male circumcision in Nyanza, Kenya at scale: The cost and efficiency of alternative service delivery modes. *BMC Health Services Research, 14*(1), 31. https://doi.org/10.1186/1472-6963-14-31

Menon, V., Gold, E., Godbole, R., Castor, D., Mahler, H., Forsythe, S., … Njeuhmeli, E. (2014). Costs and impacts of scaling up voluntary medical male circumcision in Tanzania. *PLoS One, 9*(5), e83925. https://doi.org/10.1371/journal.pone.0083925

Mwenge, L., Sande, L., Mangenah, C., Ahmed, N., Kanema, S., D'Elbée, M., … Terris-Prestholt, F. (2017). Costs of facility-based HIV testing in Malawi, Zambia and Zimbabwe. *PLoS One, 12*(10), e0185740. https://doi.org/10.1371/journal.pone.0185740

Tchuenche, M., Njeuhmeli, E., Schütte, C., Ngubeni, L., Choge, I., Martin, E., … Forsythe, S. (2018). Voluntary medical male circumcision service delivery in South Africa: The economic costs and potential opportunity for private sector involvement. *PLoS One, 13*(12), e0208698. https://doi.org/10.1371/journal.pone.0208698

Tchuenche, M., Palmer, E., Hate, V., Thambinayagam, A., Loykissoonlal, D., Njeuhmeli, E., & Forsythe, S. (2016). The cost of voluntary medical male circumcision in South Africa. *PLoS One, 11*(10), 1–17. https://doi.org/10.1371/journal.pone.0160207

UNAIDS. (2016). *Prevention Gap Report 2016.* Geneva: UNAIDS. Retrieved from http://www.unaids.org/sites/default/files/media_asset/2016-prevention-gap-report_en.pdf

Vassall, A., Sweeney, S, Kahn, J., Gomez, G. B., Bollinger, L., Marseille, E., … Levin, C. (2017, September). *Reference Case for Estimating the Costs of Global Health Services and Interventions. Global Health Cost Consortium.* https://ghcosting.org/pages/standards/reference_case

World Bank. (2019a). GDP Deflator (base year varies by country) – *United States*. Washington DC: World Bank. https://data.worldbank.org/indicator/NY.GDP.DEFL.ZS?locations=US

World Bank. (2019b). Official exchange rate (LCU per US$, period average). Washington DC: World Bank. https://data.worldbank.org/indicator/PA.NUS.FCRF?locations=BF

World Bank. (2019c). World Bank Country and Lending Groups. Washington DC: World Bank. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups