

Costs and Cost-Effectiveness of HIV Counselling and Testing Modalities in Southern Mozambique

Jun Hao Choo (✉ junhao_88_2@hotmail.com)

Imperial College London <https://orcid.org/0000-0003-3803-8488>

Elisa Lopez-Varela

Universitat de Barcelona

Laura Fuente-Soro

Universitat de Barcelona

Orvalho Augusto

Universidade Eduardo Mondlane

Charfudin Saco

Centro de Investigacao em Saude de Manhica

Ariel Nhacolo

Centro de Investigacao em Saude de Manhica

Stanley Wei

Centers for Disease Control and Prevention

Denise Naniche

Centro de Investigacao em Saude de Manhica

Ranjeeta Thomas

Imperial College London

Elisa Sicuri

Imperial College London

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Abstract

Objective: Despite the high HIV associated burden, Mozambique lacks data on HIV counselling and testing (HCT) costs. To help guide national HIV/AIDS programs, we estimated the cost per test for voluntary counselling and testing (VCT) from the patient's perspective and the costs per person tested and per HIV-positive individual linked to care to the healthcare provider for VCT, provider-initiated counselling and testing (PICT) and home-based testing (HBT). We also assessed the cost-effectiveness of these strategies for linking patients to care.

Methods: Data from a cohort study conducted in the Manhiça District were used to derive costs and linkage-to-care outcomes of the three HCT strategies. A decision tree was used to model HCT costs according to the likelihood of HCT linking individuals to care and to obtain the incremental cost-effectiveness ratios (ICERs) of PICT and HBT with VCT as the comparator. Sensitivity analyses were performed to assess robustness of base-case findings.

Findings: Average and median VCT costs to the patient per individual tested were US\$1.34 and US\$1.08, respectively. Costs per individual tested were greatest for HBT (US\$11.07), followed by VCT (US\$7.79), and PICT (US\$7.14). The costs per HIV-positive individual linked to care followed a similar trend. PICT was not cost-effective in comparison with VCT at a willingness-to-accept threshold of US\$4.53, but only marginally given a corresponding base-case ICER of US\$4.15, while HBT was dominated, with higher costs and lower impact than VCT. Base-case results for the comparison between PICT and VCT presented great uncertainty, whereas findings for HBT were robust.

Conclusion: PICT and VCT are likely equally cost-effective in Manhiça. We recommend that VCT be offered as the predominant HCT strategy in Mozambique, but expansion of PICT could be considered in limited-resource areas. HBT without facilitated linkage or reduced costs is unlikely to be cost-effective.

Introduction

Timely HIV diagnosis and linkage to care are essential for improved HIV outcomes¹ but are generally not achieved across sub-Saharan Africa (SSA).^{2,3} Haber et al. showed that in Kwazulu-Natal, the transition from receiving an HIV-positive diagnosis to care is the weakest in the HIV care continuum.⁴ A systematic review reported that, among HIV diagnosed individuals, only one-third of ART-eligible patients were receiving treatment.⁵ Cost-effective HIV counselling and testing (HCT) strategies are needed to link more people living with HIV (PLHIV) to care. Few cost-effectiveness analyses (CEAs) on HCT strategies examining linkage to care as an outcome have been conducted, although existing reports have indicated that facility-based strategies are likely more cost-effective than community-based strategies.^{6,7}

In Mozambique, where the adult HIV prevalence is among the highest in the world, only 61% PLHIV know their HIV status, and 54% are receiving ART.⁸ At the time of this study, Mozambique did not have universal HIV testing.⁹ Community-based strategies such as home-based testing (HBT) are infrequently offered.¹⁰ Voluntary counselling and testing (VCT), initiated by the patient at the health facility, has been a mainstay for HCT while provider-initiated counselling and testing (PICT) is the standard approach for healthcare services.⁹ A recent cohort study conducted in Manhiça District found that VCT was associated with the greatest proportion of PLHIV linked to care, followed by PICT and HBT.¹¹ Importantly, the study procedures did not influence the linkage-to-care beyond the HCT and facility-based referral.

Economic evidence in relation to costs and cost-effectiveness of these HCT strategies in linking PLHIV to care is lacking. By drawing on prospective data from the Manhiça cohort study,¹¹ we estimate the costs of providing HCT strategies in Mozambique and examine the cost-effectiveness of PICT and HBT compared to VCT for initiating linkage to care. In doing so, we compared the level of engagement each HCT strategy entails against the outcome.

In the literature, unit costs of HCT strategies from the provider's perspective are derived from program costs and usually reported as average cost per person tested and/or average cost per HIV-positive individual identified. The former is more relevant for our study and shall be examined in detail for VCT, PICT, and HBT. Estimates of unit costs per person tested vary. For example, VCT costs in Kenya, Swaziland, Tanzania, and Uganda were reported to be US\$8.27–US\$28.93,^{12–16} and PICT costs were lower (US\$5.71–US\$11.68).^{12–14} In Kenya, South Africa, and Uganda, several studies reported HBT costs ranging from US\$5.00 to US\$29.00 per client tested, similar to the range reported for VCT.^{13–14,17–19} Importantly, costs are not directly comparable across studies because the underlying assumptions and contexts may differ. Findings from our study can help inform policymakers on effective yet affordable national-level HCT that could help identify more PLHIV and link them to care in Mozambique.

Methods

Manhiça cohort study

In 2012, HIV prevalence and incidence in Manhiça district were estimated to be 40% and 3.6 infections/100 person-years, respectively.^{20,21} The Manhiça cohort study enrolled 1,122 participants with a new HIV-positive diagnosis (May 2014–June 2015), following routine VCT and outpatient PICT at the Manhiça District Hospital and door-to-door HBT by trained healthcare workers (Appendix 1). VCT and PICT resulted in significantly higher proportions of PLHIV linked to care, defined as enrollment in care at the reference district hospital and with a CD4 count registered within the first 3 months after HIV diagnosis, than HBT. Nonetheless, HBT reached a distinct population living in extreme poverty who were in greatest need for facilitated linkage interventions. Details of the study methods and procedures have been described elsewhere.¹¹

Cost estimate methods

We employed a micro-costing (bottom-up) approach²² to estimate the financial and economic costs of HCT provision incurred in the cohort study from the provider's perspective. As VCT and PICT were routinely offered to the public at the time of the study, estimated costs were referenced from routine health system costs. HBT-associated costs were assessed separately as HBT was not a routine testing strategy. Nevertheless, we examined only recurrent costs and not start-up costs for HBT as there was already an existing structure for carrying out door-to-door interventions e.g. community vaccination.

To determine financial costs, we processed data on capital (e.g., buildings, equipment, and vehicles) and recurrent (personnel, supplies, test-kits, and transport) costs collected May 2014–June 2015. We utilized time and motion data to determine the financial costs of personnel and transport. Time data tracked the time taken by counsellors to travel to and between participants' houses during HBT and to conduct each counselling session either at the District Hospital or at each participant's house. On the other hand, motion data included travelling speeds to determine fuel costs. We did not include training costs because HCT in the cohort study was provided by healthcare workers who were not specially trained.

The cost per VCT attendance from the patient's perspective was determined by a similar micro-costing approach using self-reported explicit costs and implicit costs. We assumed patients would not incur any additional costs for HBT and PICT.

Data sources

A questionnaire was used to elicit demographic information (Appendix 2). From the patient's perspective, data were collected from patients accessing VCT by using a specific questionnaire (Appendix 3). From the provider perspective, data were collected from VCT, HBT, and PICT using a separate questionnaire (Appendix 4). Some of the provider resources used (e.g. time to perform the test) were collected for all patients receiving the test (as their HIV status was not known a priori), but only HIV-positive patients were retained for ethical reasons. Where information on costs was not available through

questionnaires (e.g. building, furniture, and operation and maintenance costs), we approximated them as a percentage of total recurrent costs based on results from a study by Mwenge et al.²³ in Malawi and Zimbabwe, which share similar sociodemographic and economic profiles as Mozambique.^{24,25}

Data analysis

For cost estimate analysis, we included data on all individuals who tested HIV positive (n=1277), including non-enrolled individuals (n=155) who had received a HIV-positive test result previously in a concomitant study. These 155 patients were tested using the same procedure as with the other participants in the main cohort study and were included in our sample size. Of the 1277 patients, 350 were enrolled from VCT and were included in cost estimates from the patients' perspective. Time data for the following variables were highly negatively skewed due to measurement errors during data collection: travelling to individual houses, performing the test, waiting for test results, and explaining the results. We deemed the 85th percentile to be an appropriate upper limit to capture a reasonable proportion of these data without including outlying values, replacing observations above this percentile with the value at the 85th percentile. All data analyses were conducted using Microsoft Excel 2016 (V.16.14.1) and Stata (V.13.1: Stata Corporation).

We performed descriptive statistical analysis to compute mean (with standard deviation) and median (with maximum and minimum ranges) costs per person tested positive from both the patient's and provider's perspective. All costs were expressed in 2015 US\$ at an exchange rate of 33.00 Mozambique New Metical (MT) per US\$.²⁶

Determination of cost per individual tested

The cost of testing each individual was determined by summing costs of each individual resource, obtained by multiplying the quantities of each resource expended with their approximated unit costs (Appendix 5).

Indirect costs to patients were calculated by valuing their time spent travelling to and waiting at the VCT facility, using the average monthly minimum wage in Mozambique.²⁷ Capital costs were factored as a proportion of total costs. Fuel costs were calculated using motion data assuming an average travelling speed of 50 km/hour and an average fuel consumption of 0.143 L/km, based on 2013 estimates from the Global Fuel Economy Initiative.²⁸

Determination of HCT costs and cost-effectiveness

A decision tree model (Appendix 6) was designed for the CEA to determine cost-effectiveness ratios (CERs) and incremental cost-effectiveness ratios (ICERs). We defined effectiveness as linkage to care based on the cohort study's definition. Our primary outcome measure was incremental cost per enrolled individual linked to care. The model's time horizon of 1 year mirrored the duration of the cohort study.

The model captured all steps of the HIV care cascade for both VCT and PICT from diagnosis to retention in care after 12 months of follow-up. For HBT, the model additionally captured steps before the HCT process, from being reached through HBT to obtaining consent. One-year cumulative proportions, reported as the percentage uptake at each step of the HIV care cascade (figures reported in Appendix 1), were directly converted into conditional probabilities for parameterizing the decision tree (Table 1).

The key assumptions of the model were

- 1) Linear, unidirectional transitions along the care cascade; uptake at each step must be conditional on the previous step;
- 2) Only early treatment uptake (≤ 3 months post-diagnosis) at each step was modelled; and

3) Costs incurred for individuals who cannot be reached through or deemed ineligible for HBT are inconsequential to total program costs.

We calculated the expected average costs and linkage-to-care proportion per person tested for each HCT strategy, by summing costs and outcomes of each branch of the tree weighted by their associated probabilities of occurrence. A ratio of average costs and average expected linkage-to-care proportion was calculated to determine expected HCT linkage-to-care costs.

$$\text{HCT cost} = \frac{\text{Average cost per test}}{\text{Expected proportion linked to care per test among all who were tested}}$$

Unlike the derivation of CERs, data only for enrolled individuals was used to determine ICERs to facilitate accurate comparisons of effectiveness. We determined ICERs by dividing the difference in expected costs over the difference in the expected proportion of enrolled individuals linked to care.

$$\text{ICER} = \frac{\text{Average cost per test (PICT/HBT)} - \text{Average cost per test (VCT)}}{\text{Expected enrolled proportion linked to care (PICT/HBT)} - \text{Expected enrolled proportion linked to care (VCT)}}$$

Sensitivity analysis

Our univariate sensitivity analysis varied key cost-related parameters within predefined sensitivity ranges (Appendix 7) to explore the robustness of results. Lacking published data, we empirically adjusted base-case values by $\pm 20\%$, referencing ranges used by Mwenge et al. in their determination of HCT costs in three SSA countries.²³

We performed deterministic and probabilistic sensitivity analyses (DSA and PSA) as part of the CEA. In the DSA, probabilities and average costs per test were varied at the maximum and minimum values defined by their respective distributions (Table 1). In the PSA, we performed 2000 second-order Monte-Carlo simulations and plotted each result on a cost-effectiveness plane. Cost-effectiveness acceptability curves (CEACs) were constructed to determine the cost-effectiveness threshold.

Results

Costs

Costs to the provider

Base-case median costs were higher for VCT per individual tested (US\$7.82; range, US\$4.54–US\$15.14) than for PICT per individual tested (US\$7.29; range, US\$2.30–US\$14.67) but were lower than HBT per individual tested (US\$11.62; range, US\$4.32–US\$19.83; Table 2). The small difference in costs between the two facility-based strategies (VCT & PICT) can be attributed to higher personnel costs for VCT which probably resulted from a longer time spent on HCT. As expected, HBT costed more than facility-based strategies, driven by higher personnel costs and transport costs. Like VCT and PICT costs, cost component proportions of HBT costs were almost equal: personnel (32.2%), supplies (36.6%) and transport (29.6%). Resources used are reported by HCT strategy in Appendix 8.

Costs to the patient

The median base-case total cost to the patient per VCT visit was US\$1.08 (range, US\$0.00–US\$19.58). A breakdown of total costs into explicit (median, US\$0; range US\$0–US\$18.62) and implicit costs (median, US\$0.86; range, US\$0.00–US\$4.65) showed most costs (~80%) were implicit, which reflected waiting times and travelling times to the hospital (Appendix 9).

Sensitivity analysis

Average and median costs of VCT and PICT from the provider's perspective were most sensitive to variations in operation and maintenance, and capital costs (Appendix 10). However, closer examination revealed this was largely a result of high estimates obtained from reports in Kenya and Uganda, which were unlikely to represent real costs in Mozambique.^{12,13}

Although unit costs of VCT and PICT were less sensitive to test-kit prices, the large extent of overlap between them in the sensitivity analysis suggested that accurate determination of these prices is crucial, since the order of costs could differ should assumptions change. On the other hand, HBT costs were most sensitive to the choice of percentile cut-off for the upper limit of several time-related variables. Median HBT cost was especially sensitive to the low estimate, varying from the base-case value by 41%. Base-case average and median VCT costs from the patient's perspective were generally robust (Appendix 11).

HCT costs and cost-effectiveness of HCT to link to care

Base-case results

The costs per HIV-positive individual linked to care, covering both testing and linkage cost, were estimated at US\$289.67 for VCT, US\$121.46 for PICT, and US\$643.37 for HBT (Table 3). PICT was less expensive than VCT but also resulted in a lower proportion of PLHIV linked to care. The PICT ICER of US\$4.15 per additional enrolled individual linked to care was in the low cost/worse outcome quadrant of the cost-effectiveness plane (Appendix 12). In comparison with VCT, the HBT ICER (-US\$8.57) was in the high cost/worse outcome quadrant.

Table 3: Base-case results of HCT costs and cost-effectiveness comparisons between PICT & VCT and HBT & VCT

		VCT	PICT	HBT
HCT costs	Average cost per test*, US\$	7.79	7.14	11.07
	Expected proportion of HIV ⁺ individuals linked to care among those tested	0.0269	0.0588	0.0172
	Cost per HIV⁺ individual linked to care, US\$	289.67	121.46	643.37
Cost-effectiveness comparisons	Effect – Expected proportion of HIV ⁺ individuals linked to care among those enrolled only	0.621	0.466	0.238
	Incremental cost, US\$	-	-0.65	3.28
	Incremental effect	-	-0.155	-0.383
	ICER	-	4.15	-8.57 (Dominated)[#]

Note: All costs are reported to 2 decimal places. All other figures are reported to 3 significant figures.

*Assume cost per person tested positive is equivalent to cost per test.

[#]A dominated scenario occurs when the comparator, in this case VCT, is less costly but more effective than HBT. HBT is said to be dominated by VCT.

Abbreviations: PICT, provider-initiated counselling and testing; HBT, home-based testing; VCT, voluntary counselling and testing; ICER, incremental cost-effectiveness ratio.

Sensitivity analyses

HCT costs per individual linked to care were most sensitive to the average cost per test (Appendix 13-14). However, within the narrower ranges elicited from the sensitivity analysis for unit costs, base-case linkage-to-care costs for VCT and PICT were robust. Unfortunately, there was still great uncertainty in the determined HCT costs of HBT.

Similarly, ICERs were most sensitive to unit costs per test although they too were fairly robust within the narrower ranges obtained from the sensitivity analysis for unit costs (Appendix 15). Both the DSA and PSA showed significant uncertainty in determining the cost-effectiveness of PICT in relation to VCT, notwithstanding considerations of the cost-effectiveness threshold. HBT, however, was likely a dominated strategy. The probabilistic results were similar to the deterministic findings (Figure 1).

The interpretation of ICERs in the low cost/worse outcome quadrant for the PICT comparison is dependent on the minimum willingness-to-accept (WTA) for every individual successfully linked to care. As there was no clearly defined WTA threshold, a CEAC was constructed (Figure 2). Since the elicited threshold of US\$4.53 was greater than the base-case and average ICER in the PSA, we concluded PICT was not cost-effective relative to VCT, although this result was only marginal. Moreover, both the DSA and PSA indicated significant uncertainty in this result. Interestingly, both strategies had almost equal likelihood of being cost-effective when the cost-effectiveness threshold was mapped on the Monte-Carlo plot (Appendix 16). A CEAC was not produced for the comparison between HBT and VCT because HBT was clearly dominated (high cost/worse outcome) at all cost-effectiveness thresholds above zero, i.e., the corresponding CEAC is a flat horizontal line at $y=0$.

Discussion

To our knowledge, this is the first study in Mozambique to estimate costs and cost-effectiveness of VCT, PICT, and HBT. We found the median cost per VCT attendance to be as low as US\$1.00, largely comprising implicit costs. This is commensurate with VCT prices and patients' willingness-to-pay reported elsewhere,^{33,34} suggesting that the costs to patients were reasonable. However, differences in health systems, wage structure, and socioeconomic conditions between countries may lead to different valuations of explicit and implicit costs.

We found the average cost to the provider per individual tested and derived costs per HIV-positive patient linked to care to be greatest for HBT, followed by VCT and PICT. Both the magnitude and trend of costs elicited were mostly consistent with the available literature for neighboring SSA countries (in 2009 prices), with the exception of the study by Menzies et al (in 2007 prices).¹²⁻¹⁴ Notwithstanding considerations for effectiveness, PICT is the cheapest for potential HCT scale-up in areas with inadequate coverage. However, in resource-limited Mozambique, HCT scale-up requires more than mere consideration of HCT costs as improvement of existing healthcare infrastructure and expansion of the healthcare workforce are also needed.

We found HBT to be significantly more expensive than VCT and PICT. This was not consistent with the available literature. Five studies across Uganda, Kenya, and South Africa reported HBT costs ranging from US\$5.00–US\$29.00 per client tested that were in several cases lower than reported VCT and PICT costs.^{13,14,17-19} A difference in cost analysis approach likely accounts for this discrepancy, since reported cost estimates from a program perspective are more likely to capture economies of scale accurately, particularly for HBT. Another reason could be the numerous far-lying residential areas in Manhiça,²⁰ which probably required substantial resources for HBT.

CEA results suggested PICT was not cost-effective to link PLHIV to care, relative to VCT. However, this result was only marginal. Moreover, the lack of robustness in the base-case results of the CEA comparing PICT and VCT, coupled with the fact that PICT was consistently reported to be cheaper than VCT^{12,14} yet with almost comparable linkage-to-care

proportions,^{6,35} suggests a high possibility that PICT could be considered cost-effective as well, especially in areas with limited resources. PICT could be considered for expansion and scale-up, depending on the context and available resources, in line with regional trends.^{36–39} For example, in remote areas where health facilities may be understaffed, PICT could be expanded to include the general population to lower costs of HCT but still yield reasonable linkage-to-care proportions. Conversely, in areas with more resources and likely higher WTA, PICT could be limited.

As expected, HBT was more expensive and had a lower expected linkage-to-care proportion than VCT. This was consistent with several studies.^{18,40–45} However, other reports showed high linkage-to-care proportions for HBT (47.5–70.0%).^{46–50} Although definitions of linkage to care were inconsistent in the literature, Kiene et al. highlighted an obvious but important trend: HBT programs that facilitate linkage perform better than those that do not.⁵¹ Sharma et al.'s systematic review of 126 studies confirmed this trend, showing high linkages to care for strategies that facilitated linkages.⁶ Moreover, the Manhiça cohort study investigators also hypothesized that strategies to facilitate linkage to care were important for cost-effectiveness.¹¹ HBT could be cost-effective if integrated with facilitated linkage strategies.

Our study had limitations. Because data were only available for PLHIV, we modelled total program costs. The inability to determine real program costs may limit the usefulness of our findings for policymakers.⁵² Moreover, the lack of methodological consistency between our study and published studies may result in overestimates and bias cost comparisons. In Mozambique, some HIV-testing costs are borne by the government and others by international donors; our study did not distinguish between the two. In addition, analysis of costs to the provider did not include other costs, such as training, supply chain, and program management. HBT, as analyzed in this study, referred to door-to-door universal testing, and results cannot be extrapolated to other forms of community testing, such as index case testing, which is prominent in SSA testing programs.

Results from this study are hardly generalizable to other countries. Manhiça is a small, semi-rural district in Mozambique where HCT services are offered free-of-charge at district hospitals. It is unclear how the imposition of charges, like in Kenya and Tanzania,^{33,34} would influence HCT uptake and linkage-to-care. The representativeness and precision of this study's findings may also be limited since only data from a single cohort study were used, and findings are subject to limitations in that study. For example, López-Varela et al. acknowledged that attrition in linkage to care in the cohort study could have been overestimated due to poor record keeping. However, such overestimation is likely lower than in other studies because the authors used data from the Health and Disease Surveillance System.¹¹

Because our dataset lacked detailed cost information, we were unable to evaluate the combination of VCT with either PICT or HBT against standalone VCT. Future studies, however, could investigate such combinations and provide information to policymakers on how best to improve existing HIV-testing policies in Mozambique.

A CEA may be unsuitable for assessing the utility of HBT to meet targets for HIV eradication. CEAs are often designed to maximize efficiency at the expense of achieving distributive equality and equity.⁵³ Therefore, active HCT approaches, such as HBT, are seldom favored over more passive strategies due to their high unit costs per outcome achieved. Nevertheless, such strategies play a crucial role in achieving HIV eradication. To eliminate, HBT might not be cost-effective but may be equitable because HBT can reach populations distinct from those reached by facility-based strategies.¹¹ CEAs can address health equity concerns either through an equity impact analysis or an equity trade-off analysis as introduced by Cookson et al.⁵⁴ Round et al.'s analytical framework, which uses equity weights in decision analyses, may be useful.⁵⁵ Addressing equity is relevant for HCT strategies because factors like age, sex, and socioeconomic status may result in differential rates of uptake and linkage to care.^{11,56,57}

Declarations

Ethics approval and consent to participate: This study was approved by the Mozambican National Bioethics Committee and the Institutional Review Boards at the Hospital Clinic of Barcelona (Spain) and the Manhica Health Research Centre. It was also reviewed according to Centers for Disease Control and Prevention (CDC) human research protection procedures and was determined to be research; however, CDC was not engaged directly with research participants. The purpose of the main study was explained to participants, and written informed consent was obtained.

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: JHC cleaned the data, performed the economic analysis, and was also a major contributor in writing the manuscript. RT and ES provided guidance on the method of data analysis. All authors read and approved the final manuscript.

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Tables

Due to technical limitations, table 1, 2 is only available as a download in the Supplemental Files section.

Figures

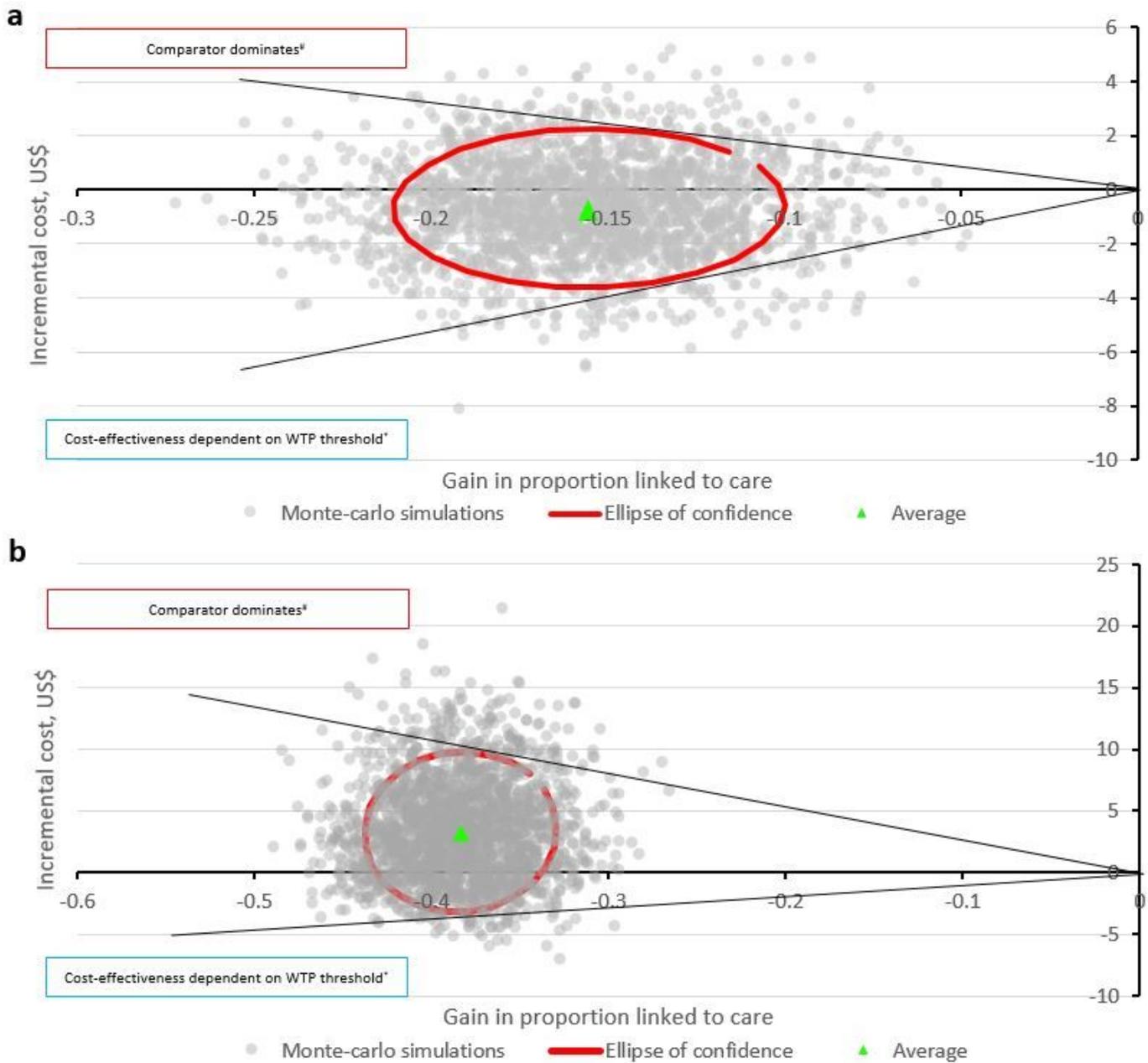


Figure 1

Plots of 2000 second-order Monte-Carlo simulations of incremental cost per proportion linked to care gained on high cost/worse outcome and low cost/worse outcome quadrants of the cost-effectiveness plane. 1a Monte-Carlo simulations for the comparison between PICT and VCT; 1b Monte-Carlo simulations for the comparison between HBT and VCT.

*Interpretation of ICERs in the low cost/worse outcome quadrant is dependent on the WTA threshold. #ICERs in the high cost/worse outcome quadrant represent a dominated scenario for the strategy under comparison. Note: The red ellipse of confidence encircles 95% of the bootstrapped ICERs, and black solid lines represent quasi 95% confidence intervals. 1a ICERs have almost equal chance of falling into the high cost/worse outcome and low cost/worse outcome quadrants. 1b ICERs are more likely to fall in the high cost/worse outcome quadrant. Abbreviations: PICT, provider-initiated counselling

and testing; HBT, home-based testing; VCT, voluntary counselling and testing; ICER, incremental cost-effectiveness ratio; WTA, willingness to accept.

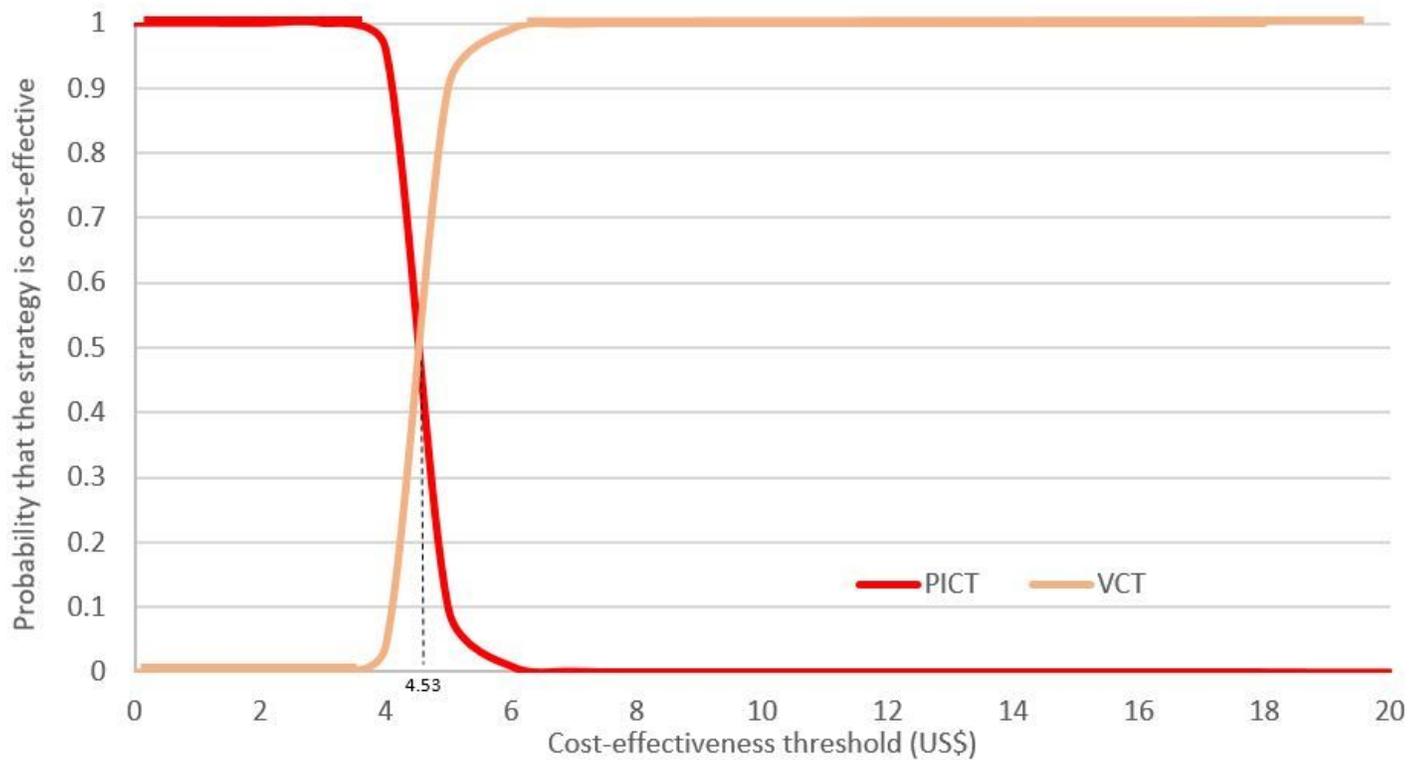


Figure 2

CEAC of the comparison between PICT and VCT. The interpretation of ICERs in the low cost/worse outcome quadrant is dependent on the cost-effectiveness threshold or the minimum WTA. PICT was initially the most cost-effective strategy up until a WTA of US\$4.53. At higher WTA, VCT was undoubtedly the more cost-effective strategy. Abbreviations: CEAC, cost-effectiveness acceptability curves; PICT, provider-initiated counselling and testing; VCT, voluntary counselling and testing; ICER, incremental cost-effectiveness ratio; WTA, willingness to accept.

Supplementary Files

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