Cost-effectiveness of voluntary HIV-1 counselling and testing in reducing sexual transmission of HIV-1 in Kenya and Tanzania

Michael Sweat, Steven Gregorich, Gloria Sangiwa, Colin Furlonge, Donald Balmer, Claudes Kamenga, Olga Grinstead, Thomas Coates

Summary

Background Access to HIV-1 voluntary counselling and testing (VCT) is severely limited in less-developed countries. We undertook a multisite trial of HIV-1 VCT to assess its impact, cost, and cost-effectiveness in less-developed country settings.

Methods The cost-effectiveness of HIV-1 VCT was estimated for a hypothetical cohort of 10,000 people seeking VCT in urban east Africa. Outcomes were modelled based on results from a randomised controlled trial of HIV-1 VCT in Tanzania and Kenya. Our main outcome measures included programme cost, number of HIV-1 infections averted, cost per HIV-1 infection averted, and cost per disability-adjusted life-year (DALY) saved. We also modelled the impact of targeting VCT by HIV-1 prevalence of the client population, and the proportion of clients who receive VCT as a couple compared with as individuals. Sensitivity analysis was done on all model parameters.

Findings HIV-1 VCT was estimated to avert 1104 HIV-1 infections in Kenya and 895 in Tanzania during the subsequent year. The cost per HIV-1 infection averted was US$249 and $346, respectively, and the cost per DALY saved was $12.77 and $17.78. The intervention was most cost-effective for HIV-1-infected people and those who received VCT as a couple. The cost-effectiveness of VCT was robust, with a range for the average cost per DALY saved of $5.16–27.36 in Kenya, and $6.58–45.03 in Tanzania. Analysis of targeting showed that increasing the proportion of couples to 70% reduces the cost per DALY saved to $10.71 in Kenya and $13.39 in Tanzania, and that targeting a population with HIV-1 prevalence of 45% decreased the cost per DALY saved to $8.36 in Kenya and $11.74 in Tanzania.

Interpretation HIV-1 VCT is highly cost-effective in urban east African settings, but slightly less so than interventions such as improvement of sexually transmitted disease services and antiretroviral therapy available for groups such as pregnant women in high-prevalence settings. With the targeting of VCT to populations with high HIV-1 prevalence and couples the cost-effectiveness of VCT is improved significantly.

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Introduction

In 1999, there were an estimated 5·6 million new HIV-1 infections and 2·6 million deaths from AIDS. The burden of HIV-1 infection and AIDS is concentrated in less-developed countries. For example, Kenya, with a population of 28·4 million, now has about 1·6 million people infected with HIV-1, and Tanzania, with a population of 31·5 million, has an estimated 1·4 million HIV-1-infected people.

HIV interventions have been implemented in Kenya and Tanzania with assistance from foreign donors and multilateral agencies in an effort to address the profound health and social problems. Intervention efforts have included aggressive condom marketing, mass-media HIV educational efforts, peer educational efforts, and interventions targeted to specific risk groups such as truck drivers and sex workers. Despite the high concentration of HIV-1 infection in this region, few people currently have access to HIV-1 voluntary counselling and testing (VCT) services, which have been shown to reduce HIV-1 transmission. In Uganda, for example, there is a countrywide system of low-cost HIV-1 VCT provision with centres that provide support after HIV-1 testing. Uganda is one of the few African nations in which HIV-1 prevalence has stabilised, and the widescale availability of HIV-1 VCT coupled with high-quality post-test support services has made a major contribution to the success in AIDS prevention. There is therefore growing support and demand for HIV-1 VCT services in other countries in this region.

There are compelling arguments for the provision of HIV VCT services in sub-Saharan Africa. First, individuals have a right to know their infection status to protect themselves and others from infection and so can plan for the future. Second, VCT may enable people to cope with the anxiety associated with HIV-1 serostatus. Third, early detection of HIV-1 may improve medical and psychosocial support for HIV-1-infected individuals. Finally, HIV-1 VCT promotes behaviour change in the short term. HIV-1 VCT had not been rigorously evaluated until recently. A review of 50 studies by Higgens and colleagues showed mixed results for the impact of counselling and testing on risk behaviours. Several studies showed behaviour change in association with knowledge of serostatus, with the greatest reductions in risk behaviour noted among HIV-1-infected men. In a more recent review of 35 studies the impact on behaviour was less conclusive. Several of the studies reviewed were in Africa. One study in Rwanda among a cohort of childbearing women who received HIV-1 VCT reported significantly increased condom use.

Demand for HIV-1 VCT will also probably grow in sub-Saharan Africa because of new efforts to make antiviral therapy available for groups such as pregnant women. Studies on nevirapine have shown its efficacy in stemming HIV-1 transmission from mother to child, and efforts are being made to make these therapies more widely available in less-developed countries.
have also been various policy efforts to make zidovudine available to African populations at a lower cost.\textsuperscript{18,19} The increased use of antiviral drugs in less-developed countries will require increased HIV-1 VCT.\textsuperscript{20}

Despite the efficacy of HIV-1 VCT in reducing risk behaviours, doubts remain about the long-term impact of HIV-1 VCT on risk behaviours; low rates of disclosure among people who have received HIV-1 VCT; negative social and psychological outcomes of HIV-1 VCT for some individuals;\textsuperscript{21,22} and the lack of behaviour change among some individuals who receive HIV-1 VCT.\textsuperscript{13} The cost-effectiveness of HIV-1 VCT in less-developed countries has not been systematically examined, and the cost of VCT is a crucial factor in the feasibility of antiviral therapies in these countries.\textsuperscript{17}

We therefore undertook an incremental cost-effectiveness analysis of HIV-1 VCT in Nairobi, Kenya, and Dar es Salaam, Tanzania, by comparing pre-intervention and post-intervention outcomes.

**Methods**

**Intervention**

The primary outcomes were generated from behavioural measures, and the modelled effects of behaviour change on HIV-1 incidence and DALYs saved from the intervention. We took a programme perspective for the analysis, and our primary research question was, “What are the health benefits of investment in HIV-1 VCT programmes?”

Details of the trial and intervention are described in the accompanying paper.\textsuperscript{4} The study was carried out from 1995 to 1998. In Kenya, a free-standing clinic was established in a poor neighbourhood of Nairobi with a high population density. In Tanzania, the study site was a free-standing clinic on the grounds of Muhimbili Hospital, the national teaching hospital in metropolitan Dar es Salaam. Both sites were easily accessible to prospective clients. An additional study site was established in Port of Spain, Trinidad. The cost-effectiveness of the intervention there is being analysed separately because Trinidad has significantly lower HIV-1 prevalence than the African sites, and because the costs of the intervention differ substantially because labour and infrastructure costs are higher than in the east African sites.

People enrolled in the study were randomly assigned either HIV-1 VCT or a video-based HIV-1 health-education intervention. The effect of the intervention was measured in a cohort of 716 participants (median age 27 years [range 17–69]) in Nairobi and 601 (median age 26 years [17–65]) in Dar es Salaam. Comparisons in study outcomes were made with a similar group of participants assigned health education. Participants assigned health education were given free access to HIV-1 VCT after their 6-month assessment. By design the study sought to enrol 50% women and 33% of clients as couples. Actual enrolment resulted in 50% women in Kenya and 45% women in Tanzania, and 34% of participants enrolled as couples in Kenya and 35% as couples in Tanzania.

We present an incremental cost analysis of HIV-1 VCT compared with no intervention by use of the effects before and after the intervention. We adapted this approach rather than using data from the comparison study group because the health-education intervention is not replicable. Clients came to the study site primarily to receive HIV-1 VCT, and thus the effects of the health-education intervention on behaviour change cannot be generalised to a replicable intervention.

**Estimation of DALYs saved**

To estimate the number of DALYs saved, we first estimated the mean age of participants (29 years). We then calculated the number of DALYs lost from an HIV-1 infection due to both disability associated with AIDS and premature death from AIDS. We estimated that the life expectancy of a person aged 29 years in Kenya and Tanzania was about 40 years based on a review of available demographic data.\textsuperscript{23,24} This life expectancy estimate is based on average life expectancy irrespective of HIV-1 infection for the base-case analysis. Comparisons are made between the life expectancy with and without AIDS. Disability weights for HIV-1 infection and AIDS were estimated to be 0.123 and 0.505, respectively.\textsuperscript{25} Disease progression parameters were adapted from published data\textsuperscript{26} that approximate an 8-year estimate for moving from HIV-1 infection to AIDS and a 1-year progression from AIDS to death, as identified by UNAIDS for less-developed countries. We adjusted the number of DALYs saved by age and discounted the number of DALYs saved to reflect age preferences.\textsuperscript{27} Future costs and benefits were discounted at a rate of 3%, with sensitivity analysis for 0 and 6%. The total number of DALYs saved from the intervention was calculated by multiplying the annual number of infections averted by the number of DALYs from disability and early mortality saved per HIV-1 infection averted.

**Measurement of costs**

Intervention costs were calculated from estimates of the per-client quantity of goods and services used in delivery of the intervention. These were derived from cost worksheets developed for the project, project records, budgets, and interviews with project staff and managers. All research costs were subtracted and the final cost estimates used were adjusted by examination of actual costs of service provision when the research was terminated and each site transferred to pure service provision. The per-client cost of the intervention estimated reflects a free-standing clinic with capacity to process 3000 clients per year. The results of the analysis are presented per 10 000 clients under the assumption of multiple clinics operating in a given setting, and also to allow for easier comparison with other cost-effectiveness analyses. An annual discount rate of 3% was used in the base-case analysis. All costs were converted to US$ for presentation by use of 1998 currency conversion rates of 600 Tanzanian shillings and 63.9 Kenyan shillings per US$.

**Study model**

Estimates of the number of HIV-1 infections averted were derived from the following probability-based formula:\textsuperscript{28}

\[
\text{Probability of HIV-1 infection} = 1 - [P(1-R(1-FE))]^{a+b+(1-P)}
\]

where P is the average HIV-1 prevalence among sexual partners of the target population, R the risk of HIV-1 transmission per act of unprotected sex (infectivity), F the fraction of sex acts when a condom is used, E the effectiveness of condoms, N the average number of sex
acts per partner, and \( M \) the average number of sex partners. Model estimates were calculated separately by combinations of HIV-1 infection status, sex, and enrolment in the study as a couple or individual (eight groups). Analysis for HIV-1-infected individuals reflects the number of HIV-1 infections that result from contact with HIV-1-uninfected sexual partners. For HIV-1-uninfected individuals, the model estimates the likelihood of their becoming infected with HIV-1 from their infected sexual partners. Thus, prevalent HIV-1 infections are excluded from analysis for those receiving HIV-1 VCT and their sexual partners. In high-prevalence settings, exclusion of prevalent HIV-1 infections from the analysis is important in making an accurate estimate. The model makes estimates of the number of HIV-1 infections that are likely to occur among HIV-1-uninfected people only. Each model variable was based on data from baseline and 12-month interviews. The analytical timeframe of the analysis reflects the impact of an averted HIV-1 infection on lifetime DALYs saved. As with other health interventions, the client receiving the intervention may have become infected at a point beyond the 1-year assessment period. Thus, the estimation of life-expectancy for calculation of DALYs saved reflects the population-level effect of AIDS mortality independently of the intervention effect.

Sensitivity analysis

We also did sensitivity analysis on the number of DALYs saved per HIV-1 infection averted with a large range of values to examine the effect of potential relapse in the intervention effect. Additional studies on the long-term impact of the intervention will be needed to assess the effect of relapse into risk behaviour more accurately, and impact of the intervention will be needed to assess the intervention effect. Additional studies on the long-term values to examine the effect of potential relapse in the index case. Sensitivity analysis was done on this parameter for values 33\% higher and 33\% lower than the base-case.

For HIV-1-infected cases, we adjusted the HIV-1 prevalence parameter for their sexual partners to 10\% lower than the HIV-1 prevalence of the study population, on the assumption that HIV-1-uninfected people are sexual networks with lower HIV-1 prevalence than HIV-1-infected clients. Sensitivity analysis was done on this parameter by setting the value as equal to that of the study population, and at 20\% lower than that value. HIV-1 infectivity values come from published data and were adjusted for sex and coinfection with sexually transmitted diseases. HIV-1 infectivity was assumed to be 0.02 per sex act between an infected man and an uninfected woman, and 0.01 per sex act between an infected woman and an uninfected man. In the presence of genital ulcerative or non-ulcerative disease in either partner, the rate of transmission was assumed to be 0.06. After adjustment for sex and observed sexually transmitted disease, we estimated that the overall HIV-1 infectivity rate was 0.0187 in Kenya and 0.0172 in Tanzania. Again, the HIV-1 infectivity parameter was adjusted for sex and coinfection within each stratum of analysis. Sensitivity analysis was done on the HIV-1 infectivity parameter with values 33\% higher and 33\% lower than these rates.

Epidemiological parameters

Base-case values for epidemiological model parameters are shown in table 1. HIV-1 seroprevalence was 20\% (95\% CI 17–23) in both Kenya and Tanzania. We assumed that the HIV-1 prevalence for sexual partners of HIV-1-infected study participants was equal to that of the index case. Sensitivity analysis was done on this parameter for values 33\% higher and 33\% lower than the base-case. For HIV-1-uninfected cases, we adjusted the HIV-1 infectivity parameter for sex and observed sexually transmitted disease, we estimated that the overall HIV-1 infectivity rate was 0.0187 in Kenya and 0.0172 in Tanzania. Again, the HIV-1 infectivity parameter was adjusted for sex and coinfection within each stratum of analysis. Sensitivity analysis was done on the HIV-1 infectivity parameter with values 33\% higher and 33\% lower than these rates.

Sexual behaviour parameters were derived from specific questions asked to study participants about number and type of sexual partners, number of sexual acts in which a condom was used, and how many times the condom ruptured or slipped when used. These data were collected at baseline and at 6-month and 12-month follow-up. We used data from the baseline and 12-month surveys to estimate the degree of

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behaviour change over 1 year. We likewise used the baseline, 6-month, and 12-month behavioural data to cross-check the validity of annualisation of model parameters for the sexual contact rates (number of partners and number of acts per partner). Survey questions assessed behaviours during the 2 months before the interview. Values for the average number of sex acts per partner were annualised (the 2-month value was multiplied by 6). The average number of sexual partners during the previous 2 months was assumed to be the same as the annual number of sexual partners, and would probably only be higher than the 2-month rate. Thus, we considered this to be a conservative estimate. We also examined variations in the number of sexual partners and contacts per partner across the baseline, 6-month, and 12-month interview data for the group not receiving HIV-1 VCT and found that the sexual contact rate over an annual period was similar to the annualised 2-month rate.

Condom use for study participants receiving HIV-1 VCT in Kenya and Tanzania increased significantly (table 1). The average annual number of sexual acts per partner decreased in both countries. However, the average number of sexual partners increased in Kenya and Tanzania. Sensitivity analysis was done on these sexual behaviour parameters with the upper and lower bounds of the 95% CI.

### Economic parameters

The cost per client to provide HIV-1 VCT and the associated percentage of total costs by item are shown in table 2. These data are based on observed costs. A range of estimated costs was also collected at each study site and is based on a detailed cost sheet completed by the clinic staff and management. In this exercise, each cost item was assigned a high, average, and low unit value and a high, average, and low estimate of the annual number of units used for each item. Variations in costs were based on fluctuations in the cost of labour, commodities, and services associated with HIV-1 VCT at each site and on estimates of clinic staff who were responsible for financial management of the projects. These ranges of cost-estimates were used in the sensitivity analysis (table 2).

Rental fees were estimated for a facility that housed a staff of five counsellors, a counselling supervisor, a project manager, a phlebotomist, and a receptionist. The clinics are both free-standing clinics and each has seven to ten private rooms, a reception area, and bathroom facilities. Training costs included the costs of an annual 3-day training retreat and training materials. The VCT clinic service was advertised with posters and flyers and short weekly radio commercials. Office furniture included desks, chairs, and basic filing cabinets. A computer was purchased in each site to process clients’ records.
and $289,300, respectively. Kenya, and $28.93 in Tanzania, the overall annual cost per client to provide HIV-1 VCT, the number of DALYs saved represents the benefit of the intervention as a ratio of intervention costs to health benefits. On average, the cost per DALY saved was $12.77 in Kenya and $17.78 in Tanzania. In Kenya and Tanzania the most cost-effective group to target was HIV-1-infected men presenting as part of a couple. HIV-1 VCT was also very cost-effective for HIV-1-infected men and women presenting as individuals in both countries. In Tanzania, HIV-1 VCT was also especially cost-effective for HIV-1-infected women presenting as part of a couple.

### Results

All results are expressed in terms of the effect per 10,000 people exposed to the intervention. This number was also a reasonable estimate of the number of clients who might be exposed to the intervention in a typical year in an urban setting with several clinic sites of similar scope to those in our study. Table 3 shows the overall outcome values across the entire study population, and by combinations of enrolment as a couple or individual, sex, and HIV-1 serostatus. For subgroup analyses, estimates of all epidemiological parameters were derived and used in the model separately. The overall values represent the outcomes when the base-case values were used and were calculated by applying the base-case values for subpopulations (combinations of sex, HIV-1 infection, and enrolment as couple or individual) and then summed for an overall value. At a per-client cost of $26.65 in Kenya, and $28.93 in Tanzania, the overall annual programme costs for 10,000 clients would be $266,500 and $289,300, respectively.

Over 1 year, HIV-1 VCT would avert 1104 HIV-1 infections in Kenya and 895 cases in Tanzania per 10,000 clients exposed to the intervention. The largest absolute number of HIV-1 infections averted is associated with HIV-1-infected women who receive HIV-1 VCT as individuals, followed by HIV-1-infected women who receive the intervention together with a sexual partner. However, the group that benefits most in terms of the proportion of HIV-1 infections averted is HIV-1-infected women and men enrolled as a couple (table 3). This group is followed by HIV-1-infected men and women presenting as individuals.

The cost per HIV-1 infection averted averaged $249 for Kenya and $346 for Tanzania. The difference between the two sites is mainly a result of the low degree of behaviour change among HIV-1-uninfected men in Tanzania who received HIV-1 VCT as individuals. These men were especially resistant to behavioural risk reduction. The cost per DALY saved represents the benefit of the intervention as a ratio of intervention costs to health benefits. On average, the cost per DALY saved was $12.77 in Kenya and $17.78 in Tanzania. In Kenya and Tanzania the most cost-effective group to target was HIV-1-infected men presenting as part of a couple. HIV-1 VCT was also very cost-effective for HIV-1-infected men and women presenting as individuals in both countries. In Tanzania, HIV-1 VCT was also especially cost-effective for HIV-1-infected women presenting as part of a couple.

### Sensitivity analysis

Since many of the parameters in the model are based on assumptions and adjustments to observed data, and since they can vary in different settings, we did a sensitivity analysis to examine how outcomes are affected by variations in input values (tables 4 and 5).

In one-way sensitivity analysis, the model is insensitive to moderate changes in HIV-1 prevalence among the sexual partners of HIV-1-infected and uninfected individuals. This finding indicates that there is a large enough pool of uninfected contacts for HIV-1 transmission to occur, even in high prevalence settings such as urban Kenya and Tanzania. Variation in the sexual behaviour parameters also somewhat affects the model outcomes, although the 95% CIs were not so wide that they had significant effects on the base-case estimates. Changes in HIV-1 infectivity also affect the model outcomes, although not sufficiently to raise concerns over the validity of the results. The cost-effectiveness of the intervention is also sensitive to the cost per client to provide HIV-1 VCT, the number of DALYs per HIV-1 infection averted, and the discount rate used.

Multiway and multivariate sensitivity analyses are shown in table 5. In the worst-case scenario, with all model parameters set to be least advantageous to a cost-effective outcome, the cost per DALY saved was $27.36 in Kenya and $45.03 in Tanzania. The best-case scenario shows HIV-1 VCT to cost $5.16 in Kenya and $6.58 in

<table>
<thead>
<tr>
<th>Overall</th>
<th>Enrolled as a couple</th>
<th>Enrolled as an individual</th>
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<td>23</td>
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<tr>
<td>Tanzania</td>
<td>601</td>
<td>17</td>
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### Table 3: 1-year cost-effectiveness of HIV-1 VCT per 10,000 clients

- **Cost per HIV-1 infection averted (US$)**
  - Kenya: 249
  - Tanzania: 296

- **Cost per DALY saved (US$)**
  - Kenya: 12.77
  - Tanzania: 17.78

- **Number of HIV-1 infections averted**
  - Kenya: 1104
  - Tanzania: 895

- **Proportion of HIV-1 infections averted**
  - Kenya: 0.09
  - Tanzania: 0.07

- **Cost per DALY saved as proportion of population subgroup**
  - Kenya: 0.01
  - Tanzania: 0.02

- **Cost per DALY saved as proportion of HIV-1 infection subgroup**
  - Kenya: 12.77
  - Tanzania: 17.78

- **Discount rate used**
  - Kenya: 0.09
  - Tanzania: 0.07

- **Sensitivity analysis**

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This analysis also found that the cost-effectiveness of HIV-1 VCT can be significantly improved through reasonable targeting approaches. Combined targeting of couples and HIV-1-infected individuals would have an even greater impact on the cost-effectiveness and feasibility of the intervention. These sorts of targeting approaches are feasible. Targeting of HIV-1-infected clients could be accomplished through supporting VCT programmes in high-prevalence settings, by linkage of VCT to other services that reach high-prevalence populations (such as sexually transmitted disease services), and by encouraging people who showed previous risk behaviour or who were or were sexual contacts of known HIV-1-infected individuals to seek VCT. Targeting of couples could be encouraged through media campaigns, from referrals from health-care providers, and by linkage of VCT to other health services that reach couples, such as antenatal clinics and family-planning programmes.

Efforts to increase access to antiviral therapies in less-developed countries will also have implications for the provision of HIV-1 VCT. Marseille and colleagues noted that, mainly because of the cost of HIV-1 VCT, universal provision of antiviral therapy such as nevirapine to women delivering children in areas of high HIV-1 prevalence may be more cost-effective than the targeting of therapy to HIV-1-infected mothers. This approach, however, does not take into account the significant benefits that the VCT itself provides, independently of the benefits of the nevirapine intervention. Thus, before decisions are made on whether to provide universal or targeted antiviral therapy for mothers and babies, the independent benefits of VCT should be included in estimations of cost-effectiveness.

Cost-effectiveness of HIV-1 VCT may also be improved through changes in the provision of the intervention. Our analysis found that the largest cost component of HIV-1 VCT was labour, followed by test kits and laboratory fees. An economy of scale could affect both of these cost components, as larger programmes could potentially use clinic and laboratory staff more efficiently, and with larger numbers of clients, programme managers might be able to negotiate discounts in the costs of laboratory kits and reagents. Such economy of scale has been achieved at the Ugandan AIDS Information Centre, a large VCT programme. The cost of providing VCT has declined significantly over time as the programme has grown (Elizabeth Marum, US Agency for International Development, Kampala, Uganda, personal communication). Care should be taken, however, because increased throughput of clients could compromise the quality of care, and with VCT, counselling is clearly an important component. Further studies on the relation between programme size and quality of care are thus needed.

Cost-effectiveness of HIV-1 VCT may also be improved with more intensive counselling efforts for those clients who do not respond well to the intervention. For example, HIV-1-uninfected men, especially those in Tanzania, who received the intervention as individuals, did not have as great a behaviour change as women or those who enrolled as couples. The VCT clinic in Dar es Salaam has since provided special training to counsellors to encourage them to spend extra time with HIV-1-negative men. Further studies should investigate why these HIV-1-negative men are more resistant to behavioural risk reduction, and what specific counselling approaches will be effective in such individuals.

Cost-sharing is another means to lower the cost of HIV-1 VCT to funding agencies and government health programmes. We assessed the willingness of clients to pay for services; after receipt of the service, they said that they would pay an average of $1.64 in Kenya and $5.11 in Tanzania. After the study ended and the sites were implemented fees based on these results. However, demand for the service declined significantly, especially in Tanzania. Therefore, each site lowered the fee to about $0.50 in Kenya and to $1 in Tanzania, and the number of clients increased to that before the initiation of fees.

There are some potential sources of error in the analysis that should be addressed. Self-report bias may have been present in the assessment of sexual outcomes. We addressed this possibility in sensitivity analysis by modelling the cost-effectiveness of the intervention with 95% CI of behavioural parameters. We found little impact on the overall findings. Self-reported risk behaviours at baseline and at 6 months were significantly associated with incident sexually transmitted diseases as shown by DNA testing of urine samples, indicating that
the self-reported sexual behaviours had a high degree of validity. 2

Biological assumptions that may have contributed error to the analysis include the possibility that rates of sexually transmitted diseases and HIV-1 infections among partners of study participants were higher or lower than assumed. Sensitivity analysis did, however, confirm that even under much higher and lower rates of infection the base-case values remained robust.

Cost estimates may also have been a source of error. Careful attention was paid to comparisons of cost estimates to actual costs incurred in service delivery, and sensitivity analysis of cost parameters showed that even at the highest estimates the base-case estimate was increased to only $17.47 in Kenya and $27.02 in Tanzania per DALY saved. At the lowest cost estimates the base-case was $8.95 in Kenya and $10.62 in Tanzania. Thus, the range still allowed for reasonable interpretation.

Other potential sources of error in the model estimates are from values derived from published data, namely the HIV-1 infectivity values used. These were derived from a careful review of previous publications, and were subjected to adjustment for sex and coinfection with sexually transmitted diseases, and were assessed in sensitivity analysis. Those analyses showed that at 33% increased and decreased infectivity the base-case values were plausible. Results for Kenya and Tanzania were similar, even in the patterns across subpopulations analysed.

The final possible limitation of the analysis was the ability to generalise the results to other settings. We believe that the services rendered in this study are very similar to other VCT services in this region, on the basis of consultations with colleagues in dissemination workshops sponsored by the project. The study population also seems to be similar to that of other services in east Africa. However, care should be taken in generalising the effectiveness of VCT to other regions, cultures, and rural settings. Despite these limitations, HIV-1 VCT may have similar effects in other settings, and there is little evidence to suggest that the effects reported here would not be found elsewhere.

Finally, this analysis focused primarily on the benefits of HIV-1 VCT in terms of infections averted and the associated DALYs saved from the intervention. However, many other tangible benefits of VCT not addressed in this analysis bolster the need to support this important intervention. First, there are significant social and psychological benefits to knowing one’s HIV-1 infection status. HIV-1 VCT gives people the ability to plan better for the future, assuages concerns over the status of their health, and gives them the ability to open discussion with sexual partners over potential risk behaviours. People should have the right to know whether they are infected with something as lethal and stigmatising as HIV-1. As antiviral therapies become more widely available in less-developed countries, the need for HIV-1 VCT will increase substantially. What is needed now is political and policy support for this intervention to make it available to the vast numbers of people currently with little access.

Chief contributors

Michael Sweat designed the study, worked with each site to develop site-specific protocols, oversaw quality assurance at the sites, did cost-effectiveness and cost-recovery analyses, and wrote most of the paper. Steven Gregorich designed the forms and data management systems, organised and carried out database management, and assisted with analyses, interpretation, and editing of the paper. Gloria Sangwati, Colin Purlonge, and Donald Balmer oversaw the study sites (Kenya, Tanzania, and Trinidad), and provided substantial input into the study design and all protocols. All site investigators had substantial input into the development of the site-specific protocol. Claudes Kamenga designed the study, worked with each site in the development of site-specific protocols, oversaw the design and implementation of the sexually transmitted disease protocol, and oversaw quality assurance at the sites. Olga Gristead developed the counselling and quality assurance protocols, supervised implementation at the local sites, did analysis on negative outcomes, and assisted in analysis, interpretation, and editing of the paper. Thomas Coates oversaw the design and execution of the study, supervised the analyses, and assisted in the interpretation and editing of the paper. All investigators had substantial input into the interpretation of results.

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