A Social Cost-Benefit Criterion for Evaluating Voluntary Counseling and Testing with an Application to Tanzania

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Summary

Rationale: There are many interventions for HIV/AIDS that require that people know their status and hence require a HIV test. Testing that is driven by a desire to prevent the spread of the disease often has an indirect effect on others. These external effects need to be identified, quantified and included as part of the benefits and costs of testing. Pioneering analyses of HIV testing by Philipson and Posner have introduced the economic calculus of individual expected benefits and costs of activities into an understanding of the HIV epidemic. What is required for social evaluations is an extension of the analysis to ensure that external effects are included.

Objectives: The objective of this paper is two-fold. First we seek to formulate cost-benefit criteria that incorporate fully the external effects in the evaluation of Voluntary Counseling and Testing (VCT). We achieve this by recasting the individual calculus of benefits and costs to a couples setting. We can then compare an individual’s cost-benefit analysis of being tested with social criteria that look at outcomes from a couple’s perspective for both separate and dual / joint testing. Second we aim to apply our social criteria to VCT programs as they currently operate in Tanzania and how these programs might operate in the future when they are scaled-up to relate to the general population.

Methodology: We develop social criteria for evaluating separate and dual VCT using a couples’ perspective with and without altruism. So the welfare function is based on two individual expected utility functions viewed as a couple, either married or regular partners. The benefits are the averted lives lost whenever discordant couples are revealed. The costs of VCT are the benefits of unprotected sex that the couple foregoes and the costs of the testing and counseling. The cost-benefit criteria are applied to VCT programs in Tanzania. The four main ingredients estimated are: the foregone benefit of unprotected sex (measured by the compensated wage differentials charged by commercial sex workers); the probability of infection; the cost of an infection (measured by both the value of a statistical life and the human capital approaches) and the cost of a single test (which includes behavior modifying counseling).
Conclusions: We find separate testing in existing VCT programs only marginally worthwhile. However, in scaled-up programs the benefit-cost ratio is over three. Dual testing is always more beneficial than separate testing. However, this advantage is reduced in scaled-up programs. VCT should be greatly expanded throughout Tanzania as future returns would be even higher for both separate and joint counseling and HIV testing.

Key Words: Cost-Benefit Analysis, Social Welfare and Externalities; Voluntary Counseling and Testing; HIV Policy; Tanzania
1. Introduction

There are many interventions for HIV/AIDS that require that people know their status and hence require a HIV test. Testing that is motivated by a desire to receive treatment need not directly affect others. However, testing that is driven by a desire to prevent the spread of the disease often has an indirect effect on others, whether they be sex partners, babies of infected mothers or recipients of blood transfusions. These external effects need to be identified, quantified and included as part of the benefits and costs of testing. Pioneering analyses of HIV testing by Philipson and Posner (1993 and 1995) – hereafter P&P – have introduced the economic calculus of individual expected benefits and costs of activities into an understanding of the HIV epidemic. What is required for social evaluations is an extension of the P&P analysis to ensure that external effects are included.

HIV testing is the major public response to the HIV/AIDS pandemic. In this context it is important that the P&P conclusion that testing not be subsidized be given deeper scrutiny. It will be shown that an individual testing separately generates an externality for the partner sharing risky sex and this would cause private levels of testing to be sub-optimal. This externality occurs after the test takes place and appears with a HIV-positive test result. The externality is manifest whenever discordant couples are identified. Subsidizing testing would not internalize this externality because it is behavior change that will reduce the externality and there is no price on risky sexual behavior to be lowered outside the commercial sex worker market. As it is behavior change that is necessary, it is important to understand that VCT is more than testing as it also includes
counseling. It is the counseling part that needs to be effective to ensure that the uninfected partner does not get infected in discordant couples (where one partner is infected and the other partner is not). So the question is whether the counseling and testing combined needs subsidization or not. There will be benefits and there will be costs. It is important that all the main categories are identified. Ultimately it is an empirical question whether the measured net benefits of VCT are positive or not. Once the case for subsidization has been established, the task of carrying out the VCT services can be undertaken by the private or public sectors, according to which one will actually have the better mix of efficiency and fairness.

The objective of this paper is two-fold. First we seek to formulate cost-benefit criteria that incorporate fully the external effects in the evaluation of Voluntary Counseling and Testing (VCT). We achieve this by recasting the individual calculus of benefits and costs to a couples setting. We can then compare an individual’s cost-benefit analysis of being tested with social criteria that look at outcomes from a couple’s perspective for both separate (one person) and dual / joint testing (one where both partners are tested together). Many empirical studies have shown that dual VCT is more cost-effective than single testing. In this paper our theoretical models suggest why this might be the case. The forgone benefits of unprotected sex, for which we will provide estimates for the first time, play a crucial role. With separate testing the couple has to give up protected sex if one partner is infected. With dual testing the couple gives up

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1 See, for example, Kamenga et al. (1991) for Zaire, Allen et al. (1992) for Rwanda, and Sweat et al. (2000) for Tanzania.
unprotected sex only if the couple is discordant. So costs will be lower in the dual testing case. Second we aim to apply our social criteria to VCT programs as they currently operate in Tanzania and how these programs might operate in the future when they are scaled-up (duplicated) to relate to the general population. We find the surprising result, for the VCT utilization and costs that pertain in Tanzania, that the more effective the program, the lower will be the benefit-cost ratio. This counter-intuitive result can be explained by the fact that the more effective the VCT program, the more discordant couples will be serviced; but because these couples will want to practice safe sex to reduce transmission, the cost in terms of foregone benefits of unprotected sex are greatly increased. Section 2 constructs the cost-benefit criteria covering dual testing, single testing, simultaneously single testing both partners, and allowing for altruism. The text has the main points and the details are presented in three Appendices. Section 3 applies the dual and single testing welfare criteria to Tanzania. Section 4 presents the summary and conclusions and deals with some extensions to the evaluation frameworks.

2. The Cost-Benefit Criterion

The cost-benefit criterion is individualistic and begins with P&P’s specification of individual utility functions.\(^2\) There are two groups of individuals in the population, men (indexed by \(m\)) and women (indexed by \(w\)) and these two groups engage in risky sexual

\(^2\) For more on the role of individualistic utility functions in CBA for health care expenditures see Brent (2004) and Brent (2006).
activities with each other. These activities generate known benefits \( B \), the value of unprotected sex, and uncertain costs \( C \), which depend on the probability that one of the partners is infected with HIV. The expected utilities from these activities are denoted \( U_m \) for the men and \( U_w \) for the women and defined as:

\[
(1) \quad U_m = B_m - p_w (1 - p_m) C_m \quad \text{and} \quad U_w = B_w - p_m (1 - p_w) C_w
\]

The probabilities \( p_w (1 - p_m) \) and \( p_m (1 - p_w) \) are the joint probabilities of becoming infected, formed by the probability of one partner being infected, \( p_w \) or \( p_m \), and the other partner being uninfected, \( (1 - p_m) \) or \( (1 - p_w) \), with these two partner events being viewed as independent. As recognized by P&P (1993, p35) this formulation is the special case where it is assumed that the transmission rate for a male equals that of a female and are both equal to 1 given that one party is infected. It is most appropriate to use this in the context of a stable partnership, such as between spouses or regular sexual partners, which is the context in which we will be developing their analysis. The

\[3\] P&P specify the two groups as male and female for convenience only. The analysis is the same if the partners are two sets of males. Also the trade need not be sexual and could involve, for example, the sharing of needles by injecting drug users. We focus on sex partners where one is male and the other is female as this is the main way that HIV is transmitted in Sub-Saharan Africa where we will be applying the cost-benefit criteria.

\[4\] Oster (2005, p479, fn7) presents a number of empirical studies which support our use of partner rather than per sexual act transmission rates. As she says, the evidence “supports a lock-and-key' interpretation of HIV transmission – infection either happens within a partnership or not.” However, she carries out her analysis with a couple's transmission rate less than 1. Our estimates of the probability \( p \) come from actual HIV prevalence rates. So the probability that one’s partner is infected incorporates past transmission possibilities. But we do not then make an allowance for the fact that, given one partner is infected, the chances that the other partner will become infected is not 1. As stated in the text, we are simplifying the analysis by just concentrating on stable, long-lasting partnerships. In the Sub-Saharan Africa context where we will be applying our CBA framework, where the transmission rate is much greater due to greater vulnerability due to malnutrition and parasitical infection – Stillwaggon (2006) – partner transmission is close to certain if one person is HIV infected.
utilities from safe sexual activities are normalized equal to zero, so the utilities in equation (1) are net of safe sex.

P&P were interested in modeling and explaining individual decision-making while we are concerned with social evaluations. The individual utility functions must therefore be embedded in some form of welfare economic criterion. The simplest way of doing this is to make the couple, the male and the female engaging in the sexual activity, the unit of analysis. The welfare unit will then be the couple’s combined utility function $U_c$ which is the sum of the two individual expected utility functions: $U_c = U_m + U_w$. Using equation (1), the criterion is represented by:

$$ U_c = B_m + B_w - p_w (1 - p_m) C_m - p_m (1 - p_w) C_w $$

Equation (2) will be applied to VCT testing before ($T'$: no test) and after testing ($T$: with test). The elements in the criterion will differ according to whether there is just single or dual testing. The difference that testing makes to equation (2) is that ex ante the probabilities $p_m$ and $p_w$ are within the unit interval $0$ and $1$, while ex post the probabilities will be exactly $0$ or $1$. The building blocks for understanding a social evaluation of VCT can be seen clearest in the case of dual testing, and we deal with this first. Before starting, we need to point out that although the unit of analysis will be in terms of a representative couple, the full welfare criterion $W$ is going to be the couples’ utility multiplied by the number of people tested $N$. That is, $W = NU_c$ and $\Delta W = N \Delta U_c$. In
our analysis $N$ will be treated as a fixed parameter determined by the VCT program. We apply $N$ as the final step at the end of the next section.

2.1 Evaluating Dual Testing

VCT is beneficial only if one learns something from the testing and then there are changes in behavior. We first examine what is learned and then consider what will be changed. With dual testing $p_m$ and $p_w$ are either 0 or 1, so there are four possible combinations and these become four cases (each one indicated by a case number subscript). Here we define the four cases and leave to Appendix A their construction:

If the man tests positive and the female tests negative, expected couple utility is:

\[(3a) \quad U_{c1} = p_m (1 - p_w) [B_m + B_w - C_w]\]

If the man tests negative and the woman tests positive, expected couple utility is:

\[(3b) \quad U_{c2} = p_w (1 - p_m) [B_m + B_w - C_m]\]

When both are tested positive, the expected couple utility is:

\[(3c) \quad U_{c3} = p_m p_w [B_m + B_w]\]

When both are tested negative, the expected couple utility is:

\[(3d) \quad U_{c4} = (1 - p_m) (1 - p_w) [B_m + B_w]\]

It is easy to check that: $U_c = U_{c1} + U_{c2} + U_{c3} + U_{c4}$. That is, the cost-benefit criterion given by equation (2) can be decomposed into the four cases given in (3a) to (3d). These four cases are what can be expected ex ante from testing. However, once testing
has taken place, self-interest ensures that the outcomes in the last two cases would not materialize. Only behavior change from cases (3a) and (3b) which relate to discordant couples are relevant. So we have the following proposition:

**Proposition 1:** If we define $\Delta U_c$ as the difference between expected couple utility before the testing with no behavior change and expected couple utility after the testing with no behavior change then for dual testing:

$$
(4) \quad \Delta U_c = p_m (1 - p_w) C_w + p_w (1 - p_m) C_m - (p_m + p_w - 2 p_m p_w) [B_m + B_w] - 2K
$$

For the derivation, see Appendix A.

The expected benefits of dual testing in equation (4) are seen to be the cost saving of the woman not being infected (weighted by the joint probability of the man being infected and the woman being uninfected) plus the cost saving of the man not being infected (weighted by the joint probability of the woman being infected and the man uninfected). The expected costs are the benefits of unprotected sex that both have to forego (weighted by the joint probability that either the man or the woman is infected when both events are not mutually exclusive) plus the cost of the two HIV tests.

Note that the role of VCT in the context of dual couples testing is straightforward. Both partners get tested, know the results and will cease from risky sex if the results are discordant. The man initiates the safe sex if the woman is infected and the woman...
initiates the safe sex if the man is infected. Counseling involves providing guidance and information for how safe sex can take place.

2.2 Evaluating Single Testing

Now consider the situation where there is a single test, say the male. Let us first see how the male would evaluate testing and then compare that with the social test. With single testing there are only two cases to analyze and one testing cost to incur. Again in the text we give the main results and leave the details to an appendix.

The expected utility for the male from risky sex if he were found positive would be:

\[
U_{m1} = p_m [B_m]
\]

Should he be found HIV negative, the expected utility would be:

\[
U_{m2} = (1 - p_m) [B_m - p_w C_m]
\]

Risky sex is more likely to make the male infected and this decreases his utility from it.

Equations (5a) and (5b) ignore the utility effects on the woman. From her perspective, these equations lead to perverse results. For in equation (5a) he is infected and he obtains higher utility from risky sex, yet will infect his partner; while in
equation (6b) he is uninfected and obtains less utility from risky sex even though there is no chance of him infecting the woman. This result is a direct implication of the P&P specification of the individual utility functions in equation (1), where a positive test \((p_m = 1)\) increases the male’s utility while decreasing the utility for the woman.

Instead let us use the social criterion given by equation (2) to analyze the two possible test outcomes for males. The couple’s counterpart to equation (5a) is:

\[
(6a) \quad U_{c1} = p_m \left[ B_m + B_w - (1 - p_w) C_w \right]
\]

and the social counterpart to equation (5b) is:

\[
(6b) \quad U_{c2} = (1 - p_m) \left[ B_m + B_w - p_w C_m \right]
\]

In the couple’s context, and with an additional axiom, behavioral change will stem only from equation (6a). The proposition is:

**Proposition 2:** If we assume that the woman would not knowingly have risky sex with an infected man if she did not know for certain that she herself was infected, and define \(\Delta U_c\) as before, then for single testing:

\[
(7) \quad \Delta U_c = p_m (1 - p_w) C_w - p_m [ B_m + B_w ] - K
\]
See Appendix B.

The expected benefit of male HIV testing is therefore the cost saving of the woman not being infected (weighted by the joint probability of the man being infected and the woman being uninfected). The expected costs are the benefits of unprotected sex that both have to forego (weighted by the probability that the man is infected) plus the cost of the HIV test.

The new axiom would be sufficient to ensure that equation (7) would involve behavior change after the test results were revealed to the male, provided that the results were also made known to the partner. It is clear from this conditionality that the roles of VCT services are different in the single test situation from that of couple testing. It is not sufficient that one just give the male the HIV positive test result. He must be persuaded by counseling to share the result with the woman to ensure that she does not get infected.

The evaluation of a female HIV test is symmetrical to that of the male and has a similar interpretation. It is represented by:

\[
\Delta U_c = p_w (1 - p_m) C_m - p_w [ B_m + B_w ] - K
\]

2.3 Joint Testing versus Single Testing both Partners
What difference does it make to have joint testing of a couple relative to both partners in a couple being tested separately? To help answer this question, we shall work with simplified versions for the dual and separate testing cost-benefit criteria. In order to fix $\Delta U_c$ we will set: $p_m = p_w = p$; $C_m = C_w = C$ and $B_m = B_w = B$. The dual testing equation (4) is replaced by:

\[
\Delta U_c = 2 \left[ p (1 - p) C \right] - 2 p (1 - p) [2B] - 2K
\]

Instead of either equation (7) or (8) we have for a single test:

\[
\Delta U_c = p (1 - p) C - p (2B) - K
\]

Both individuals being tested separately would require that equation (10) be multiplied by two to become:

\[
\Delta U_c = 2 \left[ p (1 - p) C \right] - 2 p [2B] - 2K
\]

On inspection of equations (9) and (11) it is immediately obvious that dual testing will give higher couple utility because the foregone benefits of unprotected sex are lower with joint testing by the multiplier $1 - p$. With single testing the couple has to give up unprotected sex if one partner is infected (determined by $p$); but with dual testing the couple gives up unprotected sex only if the couple is discordant [determined by $p(1-p)$].
2.4  Externalities within Couples

As we saw in section (2.2), equation (5a) gives the expected utility from risky sex in a single test setting and equation (6a) the counterpart in a joint test setting. The difference in utility (see Appendix B) is the amount: \( p_m \left[ B_w - (1 - p_w) C_w \right] \). This is the externality that becomes relevant for the case for promoting VCT on social welfare grounds. The externality consists of the possibility that when the man gets tested and is found positive for HIV that he will continue with risky sex even though the female is uninfected. Note there is no externality from single testing if the man tests HIV negative as it is his choice whether to continue with risky sex. The sign of the externality depends on the sign of \( B_w - (1 - p_w) C_w \). Given that in the P&P model the value of protected sex is normalized to zero, risky sex has a positive utility so \( B_w - C_w > 0 \), which means \( B_w - (1 - p_w) C_w > 0 \). Thus the externality is positive and joint VCT is worth subsidizing from a couple’s perspective.

In the absence of altruism (which is the P&P assumption) there is absolutely no cost for the male to continue with risky sex if he tests HIV positive. It is this that causes the externality. But, what happens if there is interdependence within utility functions such that altruism exists. Does that mean that the externality gets internalized? The following analysis addresses this issue.
Let us use stars * to relate to utility functions with altruism:

\[(12) \quad U_m^* = U_m + \alpha_m U_w \quad \text{and} \quad U_w^* = U_w + \alpha_w U_m \]

where \( U_m \) and \( U_w \) are as specified by equation (1), and \( \alpha_m \) is the man’s weighting of the woman’s utility and \( \alpha_w \) is the woman’s weighting of the man’s utility. These specifications give the couple’s joint utility as:

\[(13) \quad U_c^* = U_m^* + U_w^* = (1 + \alpha_w) U_m + (1 + \alpha_m) U_w \]

The couple’s formulation: \( U_c = U_m + U_w \) is just the special case of equation (13) where \( \alpha_m = \alpha_w = 0 \) and there seems to be no altruism. However, as explained in Appendix C: \( \alpha_m = \alpha_w = 0 \) is a form of altruism; full altruism \( \alpha_m = \alpha_w = 1 \) involves double-counting; no altruism is either \( \alpha_m = -1 \) or \( \alpha_w = -1 \); and although asymmetric altruism \( \alpha_m = 1, \alpha_w = 0 \) could internalize the externality for one partner, it would not do so for the other. The proposition is:

**Proposition 3:** The couple’s formation automatically includes altruism in some form. Altruism introduced outside the couple’s framework cannot completely internalize the externality.

See Appendix C.
In terms of our analysis, altruism basically means that there is a multiplier effect. If the original effect is not positive then multiplying the effect will not change the direction of the effect. Note that altruism means that a person cares about one's partner getting infected, but the person also cares that the partner has to give up the benefits of unprotected sex. So the impact of altruism will not automatically rule out risky sex.

2.5 The Complete Cost-Benefit Criteria

We have established expressions for the change in a couple's utility. The final step is to convert them into social welfare criteria by applying \( N \), the number of couples affected. However, we need to draw a numbers distinction. It is an almost inherent feature of any VCT program that not everyone in the program will agree to be tested even if they are advised and encouraged to do so. Thus the number of clients in the program is likely to be different from the number of clients tested. Because it is only the tested people who are likely to have their behavior affected by the VCT and produce the infection costs savings, and counseling costs apply to all those in the program (tested and untested) we will distinguish the number tested \( N^T \) from the total number of clients in the program \( N^{T+T'} \). Instead of applying a single \( N \) to \( \Delta U_c \) to form \( \Delta W = N \Delta U_c \), we shall use for a separate test related to equation (11):

\[
\Delta W = N^T [p(1-p)C] - N^{T+T'} [p(2B) + K]
\]

and for a dual test related to equation (10):

It is with these two welfare specifications (14) and (15) that we will now carry out our evaluation of VCT testing in Tanzania.

3. The Cost-Benefit Criterion Applied to VCT in Tanzania

We will be evaluating the Tanzania VCT program as it operated for the period 1997 – 2001. Table 1, based on table 14 of Ministry of Health (2002a), gives some details of the scale of operations for the 20 regions in total. The program will be examined in terms of the five-year averages.

<table>
<thead>
<tr>
<th>Year</th>
<th>New Clients</th>
<th>Clients Tested</th>
<th>HIV Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>3,465</td>
<td>1,898</td>
<td>69.7%</td>
</tr>
<tr>
<td>1998</td>
<td>3,620</td>
<td>2,579</td>
<td>65.6%</td>
</tr>
<tr>
<td>1999</td>
<td>2,548</td>
<td>2,641</td>
<td>75.8%</td>
</tr>
<tr>
<td>2000</td>
<td>6,539</td>
<td>3,338</td>
<td>59.5%</td>
</tr>
<tr>
<td>2001</td>
<td>11,501</td>
<td>7,473</td>
<td>76.1%</td>
</tr>
</tbody>
</table>

Average: 5,535     3,586     70.8%

In table 1 we see that the number of clients in the program (5,535) were different from the number of clients tested (3,586). This fixes \( N^T = 3,586 \) and \( N^{T+T'} = 5,535 \).
3.1 Measuring the Cost-Benefit Ingredients.

Unless stated otherwise, all monetary estimates will be expressed in terms of Tanzanian shillings TZSH. Since the cost figures we obtain are in 1998 prices, for convenience, all our monetary sums will be expressed in 1998 prices. US dollar values were converted into the local currency using the 1998 exchange rate of 600 TZSH per US $1.

With the $N$ numbers determined, there are four main ingredients in equations (14) and (15) that remain to be measured, viz., the (foregone) benefit $B$ of unprotected sex, the probability $p$, the cost $C$ of an infection, and the cost $K$ of a single test. We measure each of these ingredients in turn. We present our base case estimates and indicate also the alternative values that we will be using in the sensitivity analysis.

(i) Benefits of unprotected sex $B$.

An estimate of the benefits of unprotected sex can be obtained from the commercial sex worker, CSW, market. The method being applied is that of compensating wage differentials whereby the wages or prices vary according to the disutility that a person is accommodating. In this market there exists two prices, i.e., the price for unprotected sex $P^{NC}$ ($NC$: sex with no condom) and the price for protected sex $P^C$ ($C$: sex with a condom). Gertler et al. (2005) show that, in equilibrium, the price differential between these two prices is a weighted average of the benefits of unprotected sex $B$ (equivalent
in their model to the client’s disutility of condom use) and the CSW’s disutility of not using a condom $\gamma$ (because she might get infected) where the weights are given by the relative bargaining power of the client and the CSW (with $\theta$ the weight on the CSW’s disutility and $1 – \theta$ the weight on the client’s disutility). Thus:

\[
(16) \quad P^{NC} - P^C = (1 - \theta) B + \theta \gamma
\]

Using data for two states in Mexico, Gertler et al. estimated the price differential expressed in equation (16) as a percentage of the condom price. They found that a CSW received a 23% premium for unprotected sex and this rose to 46% if the CSW was considered to be attractive (a proxy measure for the bargaining power $\theta$).

In the absence of a data-driven application of the Gertler model to Tanzania, we will simply assume that $\theta = 0$ in equation (16), in which case: $B = P^{NC} - P^C$. Tanzania is a lot poorer than Mexico and HIV is more widespread in the general population. There are many more CSWs willing to offer unprotected sex. In this case, client preferences dominate and all of the price differential will reflect what they must pay for unprotected sex. We will use half of this differential in the sensitivity analysis.

The Ministry of Health (2002b) in their STIs Newsletter reported that for normal sex, in the sub-towns of Chalinze and Lugoba in the Costal region, $P^{NC} = \text{TZSH } 5,000$ and $P^C = \text{TZSH } 500$. The price differential was therefore TZSH 4,500, or TZSH 3,627.
This is the per act amount. To make this figure comparable to the lifetime costs, we will multiply this by 38 to obtain a measure of the loss of benefits per year, and then multiply by 24 years of annual sexual activity to obtain the lifetime total $B$ foregone of TZSH 3.307824 million.

(ii) The probability of infection $p$.

The probability $p$, together with $1 - p$, informs us of the chances of the program being effective. For $p (1 - p)$ indicates whether a couple is likely to be discordant or not. Only if the couple is discordant must risky behavior change in order for the costs of disease to be averted. On the basis of the 70.8% average probability figure in table 1, the Tanzanian VCT program was very effective, with around 1 in 5 couples being discordant (20.67%).

It might seem that this value for $p$ was much too high in light of the HIV rate in the general population of Tanzania. On the basis of the first nationally representative sample survey that actually tested all respondents in 2003/2004, the value for $p$ was estimated to be 7%. This would determine the share of discordant couples to be only

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6 Meekers and Van Rossem (2005), using the 1999 Demographic and Health Survey for Tanzania, estimate (on the basis of the proportion having sex the previous day) that men have an average of 36 acts per year and women have 40 and we took a simple average of the two.

7 This assumes that a person starts having regular sex at 25 (the TACAIDS’ Tanzania HIV/AIDS Indicator Survey (2005) - hereafter simply referred to as the THIS - has 95% of women and 90% of men having had sex by the age of 25 years) and ceases at the UNIDO limit of 49 years.

8 See the THIS.
However, as Boozer and Philipson (2000), explain (and find in their data analysis) the demand for testing is positively related to the probability of infection of the person. So one should expect a higher infection rate among testers than in the general population. This was confirmed by the Ministry of Health in Tanzania who, when presenting the information that appears in table 1, stated; “high risk individuals are interested to know their serostatus as opposed to the low risk ones who do not seem to utilize these services.”

Although we will take the 20% effectiveness estimate as indicative of VCT in the past, it is advisable to use the lower 6.5% estimate for future evaluations. As Glick (2005) points out, the fact that current VCT programs may be effective does not ensure that they will be effective when the scaling-up to the general population in Africa takes place. So we will use the higher figure as the effectiveness estimate used to evaluate the existing program and adopt the lower effectiveness estimate to evaluate a scaled-up VCT program.

(iii) Cost of an infection C.

In the context of HIV/AIDS in Sub-Saharan Africa, given that ARVs have been, and are still, in short supply, avoiding an infection is saving a life. From the applied welfare economist’s perspective, valuing a saved life means finding the amount of money that

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9 In the THIS the share of discordant couples was actually 8% and not 6.5% as predicted by the joint probability.

10 See Ministry of Health (2002a, p27).
someone is willing to accept for the extra risk involved with an activity that might, with a specified probability, lead to death. This is called the “value of a statistical life” VSL approach. Usually, the activity used to reveal the VSL is an occupational choice, where a job that has a higher chance of fatality has a higher wage. Apart from CSWs, sex usually does not involve a market wage, so this approach cannot be directly used for lives lost to HIV/AIDS in the general population. Instead we will use the relation developed by Miller (2000) that enables us to work with GDP per capita data instead of a wage rate. He regressed the estimated VSL in 68 studies across 13 countries on GDP and found:

\[
VSL = 136.7 \times \text{GDP per capita}
\]

None of the countries in Miller’s sample were developing countries. Unfortunately, using this regression for Tanzania means that we will be extrapolating out of sample. Nonetheless, if we use the 1998 figure for GDP per capita of TZSH 170,844 we obtain a VSL amount of TZSH 23,354 million.

The main alternative to using the VSL that is often adopted in health care evaluation is the human capital HC approach where people’s lives are valued by their productivity contribution to the economy in terms of their lifetime earnings. In applied CBA, the human capital approach comes up with a value that is about one-third of that of the VSL. Haacker’s (2006) analysis of the existence of a non-linear relationship between the VSL and life expectancy can be used to help us give an explanation as to
why there should be this 3:1 ratio between the VSL and HC. \textsuperscript{11} We present the essence of his argument using numbers that first relate to the US and then apply the analysis to Tanzania.

Ignoring discounting, lifetime earnings can be approximated by the product of an average year’s earnings (as measured by GDP per capita) and the remaining life expectancy $LE$. Thus, the value of human capital is measured by: $HC = LE \times GDP$ per capita. Consider a county that has a remaining life expectancy of 35.1, which is typical of those who estimate the VSL using the trade-off between risk and wages in the US. For such a country using the HC formula one would obtain:

\begin{equation}
HC = 35.1 \times GDP \text{ per capita}
\end{equation}

Comparing equations (17) and (18) we immediately see that for this particular $LE$, the relation between the VSL and HC is exactly 3.89 (close to the 3:1 relation found in empirical studies). The interpretation of the 3.89 is that, if one uses the VSL as in equation (17), we are weighting $LE$ by 3.89; while if we are using the HC equation (18), we are using an equal weighting scheme applied to $LE$, as each of the 35.1 years is given a weight of 1. In other words, if one uses the VSL equation (17), one is effectively using the non-linear weighting scheme $\omega$: $\omega = 136.7 \times LE^{-1}$. Thus: countries with a remaining $LE$ of 136.7 (if they existed!) they have $\omega = 1$; countries with a remaining $LE$ of 35.1 they have $\omega = 3.89$; and countries with a remaining $LE$ of 1 they have $\omega = 137.1$.

\textsuperscript{11} Haacker (2006) is an extension of the analysis in Croft and Haacker (2004).
The VSL has diminishing marginal social utility of $LE$ just as required in Haacker's formulations.

For Tanzania, in the measurement of $B$ presented earlier, we used a figure of 25 years as the age when someone is in the VCT program and 49 years when sexual activity ceases. Since life expectancy is also around 49, the 24 years of remaining lifetime sexual activity is also a good measure of the remaining lifetime expectancy for someone whose life is being saved in Tanzania by the VCT program.\(^{12}\) Thus for Tanzania, we have the HC value as: $24 \times \text{GDP per capita}$, or TZSH 4.100256 million. The VSL in the Tanzanian case is 5.70 times the HC amount, i.e., $\omega = 136.7 \times 24^{-1}$.

\[(iv) \quad \text{Cost of a client test and counseling session } K.\]

Sweat et al. (2000) carried out a cost-effectiveness study of VCT in Tanzania and we will use their cost estimates for our CBA evaluation. The cost estimates reflect a free standing clinic with a capacity to process 3,000 clients per year. The results were presented per 100,000 clients as they envisaged multiple clinics operating in the intervention. Costs were discounted at the rate of 3% in their base-case analysis which we will be using.

The cost per client for a 1-year timeframe was estimated to be TZSH 0.017358 million. These costs included operating expenditures (building rent, telephone and

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power, training, advertising, labor, HIV-1 test kits and other consumables) and capital expenditures (office furniture, computers and audiovisual equipment) that were distributed over 5 years.

3.2 The results.

The resulting costs, benefits and cost-benefit ratios for separate testing, on the basis of equation (14), are shown in table 2, and those for dual testing, derived from equation (15), are presented in table 3 (monetary amounts in tables 3 and 4 are in millions of Tanzanian shillings).

Table 2: Cost- Benefit Outcomes for Separate VCT Testing, Tanzania 1997 – 2001

|                          | Existing VCT Program | (p = 0.708) | |                          | Scaled-up VCT Program | (p = 0.070) | |
|--------------------------|----------------------|-------------|----------|--------------------------|--------------|----------|
|                          | (1)                  | (2)         | (3)      |                          | (4)          | (5)      | (6)      | (7)      | (8)      |
| C = 23.4                 | C = 4.1              | C = 23.4    | C = 4.1  | C = 23.4                 | C = 4.1      | C = 23.4 | C = 4.1  | C = 23.4 | C = 4.1  |
| B = 3.3                  | B = 3.3              | B = 1.7     | B = 3.3  | B = 3.3                  | B = 3.3      | B = 1.7  | B = 3.3  | B = 1.7  | B = 1.7  |
| Total VCT Costs          | 96.1                 | 96.1        | 96.1     | 96.1                     | 96.1         | 96.1     | 96.1     | 96.1     | 96.1     |
| Total Foregone Benefits  | 16,796.4             | 16,796.4    | 8,398.2  | 8,398.2                  | 1,660.7      | 1,660.7  | 830.3    | 830.3    | 830.3    |
| Total Costs = VCT Costs + Foregone Benefits | 16,892.5 | 16,892.5 | 8,494.3 | 8,494.3 | 1,756.7 | 1,756.7 | 926.4 | 926.4 |
| Number of Lives Lost Averted | 741.4             | 741.4       | 741.4    | 741.4                    | 233.4        | 233.4    | 233.4    | 233.4    | 233.4    |
| Benefits per person      | 23.4                 | 4.1         | 23.4     | 4.1                      | 23.4         | 4.1      | 23.4     | 4.1      | 23.4     |
| Total Benefits           | 17,313.9             | 3,039.7     | 17,313.9 | 3,039.7                  | 5,452.0      | 957.2    | 5,452.0  | 957.2    | 957.2    |
| Benefit - Cost Ratio     | 1.03                 | 0.18        | 2.04     | 0.36                     | 3.10         | 0.54     | 5.89     | 1.03     |
### Table 3: Cost- Benefit Outcomes for Dual VCT Testing, Tanzania 1997 – 2001

<table>
<thead>
<tr>
<th></th>
<th>Existing VCT Program ((p = 0.708))</th>
<th>Scaled-up VCT Program ((p = 0.070))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
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<tr>
<td></td>
<td>C = 23.4</td>
<td>C = 23.4</td>
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<tr>
<td></td>
<td>B = 3.3</td>
<td>B = 1.7</td>
</tr>
<tr>
<td>Total VCT Costs (2N^{tT} [K])</td>
<td>192.2</td>
<td>192.2</td>
</tr>
<tr>
<td>Total Foregone Benefits (N^tT 2 [ p (1-p) (2B) ])</td>
<td>9,809.1</td>
<td>4,904.5</td>
</tr>
<tr>
<td>Total Costs = VCT Costs + Foregone Benefits</td>
<td>10,001.2</td>
<td>5,096.7</td>
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<tr>
<td></td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td></td>
<td>C = 23.4</td>
<td>C = 23.4</td>
</tr>
<tr>
<td></td>
<td>B = 1.7</td>
<td>B = 3.3</td>
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<tr>
<td></td>
<td>192.2</td>
<td>192.2</td>
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<tr>
<td></td>
<td>4,904.5</td>
<td>3,088.8</td>
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<tr>
<td></td>
<td>10,001.2</td>
<td>5,096.7</td>
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<td>(5)</td>
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<td>C = 23.4</td>
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<td>C = 23.4</td>
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<td>B = 1.7</td>
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<td>192.2</td>
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<td>1,544.4</td>
<td>1,544.4</td>
</tr>
<tr>
<td></td>
<td>10,001.2</td>
<td>5,096.7</td>
</tr>
</tbody>
</table>

| Number of Lives Lost Averted \(N^tT \{ p (1-p) \}\) | 1,482.7                             | 1,482.7                             |
| Benefits per person \[C\] | 23.4 | 4.1 |
| Total Benefits \(N^tT \{ p (1-p) C\}\) | 34,627.8 | 6,079.5 |
| Benefit - Cost Ratio | 3.46 | 0.61 |

The best estimates, which form the base-line, are in column 1 of each table and the other columns show the sensitivity analysis to alternative estimates. Columns (1) to (4) represent the evaluation of the existing VCT program as these numbers correspond to high values for \(p\) (equal to 0.708) which is a characteristic of a small-scale program where only the highest risk individuals choose to participate. Columns (5) to (8) represent the evaluations for a scaled-up VCT program where participants are now typical of the population in the country as a whole, where \(p\) is the national average risk of getting HIV/ AIDS (equal to 0.07). Columns (2), (4), (6) and (8) use the HC approach instead of the VSL which appears in the base-line; and columns ((3), (4), (7) and (8) are the cases when the benefits foregone are a half of those in the base-line. Since columns (2) to (8) make adjustments to the base-line estimates, and table 3 uses the same numbers as for table 2 (albeit assembled in different formulae), we only need to clarify the numbers in column (1) in table 2.
With 5,535 clients in the VCT program and a cost per test \( (K) \) of TZSH 0.017358 million, the total VCT costs are TZSH 96.1 million. This number is used throughout.\(^{13}\) Foregone benefits \( (B) \) are TZSH 3.31 million per person. For the couple, this loss is TZSH 6.62 million. The probability \( p \) of foregoing these benefits is 0.708. For 5,535 clients the foregone benefits amount to TZSH 16,796.4 million. The VCT testing costs and the foregone benefits sum to TZSH 16,892.5 million (US $28.15 million). The probability \( p(1-p) \) of there being a life saved is 0.2067. For 3,586 persons tested, there would be 741 lives saved. Each life saved using the VSL is worth TZSH 23.36 million. So the total life-saving benefits are TZSH 17,313.9 million (US $28.86 million). Dividing the benefits by the costs we obtain a benefit-cost ratio of 1.03.

The base-line evaluation of separate VCT testing in the existing program is marginally positive, with benefits 3% higher than the costs. However, in the long-run with a scaled-up program, the outcome is very strongly positive, as the benefits are over three times the costs. Using the HC approach would make the existing program appear very inefficient. Interestingly, even with the HC approach giving benefits per person one-sixth of those using the VSL, the scaled-up VCT program would still appear worthwhile in one of the alternatives, with benefits 3% greater than the costs.

\(^{13}\) Sweat et al. found that the lowest cost per client was TZSH 0.009768 million and the highest cost was TZSH 0.028674 million. They used these as the cost alternatives in their sensitivity analysis. In our study using these cost alternatives makes very little difference to the outcomes because testing costs are such a small share of the total costs. So we just stay with the single estimate.
Dual testing, as we would expect from the comparison of formulae we carried out earlier, is uniformly more beneficial than separate testing. What was unexpected was the size of the differential in favor of dual testing. Benefit-cost ratios were around three times larger for existing programs. Just as unexpected perhaps was the finding that for scaled-up VCT programs, the differential advantage of dual testing over separate testing mainly disappears.

4. Summary and Conclusions

At the heart of the P&P analysis of HIV testing and sexual behavior generally is the axiom that it is not necessarily counterproductive for individuals to engage in activities that may turn out to leave them infected. It all depends on the size of the benefits relative to the probability weighted infection costs. This axiom needed to be embedded within a social welfare function that is positively related to individuals expected utilities. Making individuals better off, improves social welfare and, as expressed in the form of a cost-benefit outcome, this is to guide social decision-making.

The welfare function that we constructed was based on two individual utility functions viewed as a couple, either married or regular partners. This framework ensures that the external effects of a single individual test on the partner is included – effects that are missing from the P&P analysis. The main rationale for the expenditures devoted to the counseling part of VCT is that they are necessary to prevent transmission from a tested HIV positive individual to a potentially HIV negative partner.
The mechanism by which transmission is avoided is by a reduction in unprotected sex. This can be achieved by either convincing the positive individual to use condoms directly, or by convincing the individual to inform the partner so that s/he will initiate the use of condoms (or abstinence). No matter the path by which transmission is prevented, the end result is a benefit in terms of a saving of lives and a cost in terms of a reduction in the benefit of unprotected sex. In fact, these foregone benefits are the *sine qua non* for the life-saving benefits. The benefit of unprotected sex is the centerpiece in the P&P analysis. The reduction in the benefit of unprotected sex is an important ingredient that is missing from all current health care evaluations of VCT. By focusing on just the costs of the VCT program, and ignoring the other element in costs, existing cost-effective ratios calculated in the literature are greatly exaggerated. For example, in the Tanzania context, we were able to show that VCT testing costs were less than 1% of total costs in our base-line estimates and never more than 11% in any of the alternative estimates.

In our cost-benefit criteria, life saving from VCT takes place only in the context of discordant couples. Recent work by de Walque (2006) revealed surprising evidence that in five African countries, including Tanzania, at least two-thirds of the infected couples are discordant. He argues that therefore there is ample scope for prevention efforts targeted at infected couples using VCT, especially involving joint testing. In our cost-benefit analyses of VCT for Tanzania we found in our base-line estimates that both separate testing (marginally) and dual testing (greatly) were worthwhile. It would seem that our cost-benefit criteria by focusing on discordant couples is identifying a “high-risk
group” that is worth targeting in addition to the usual categories consisting of homosexuals, intravenous drug users and commercial sex workers.

Note that the importance of identifying discordant couples is not an external assumption imposed on our CBA framework for it is simply a consequence of our extension of the P&P framework. In the P&P model, \( p (1 – p) \) is the transmission probability. Transported to a couples setting the joint probability becomes the measure of effectiveness acting through discordant couples, i.e., there is transmission only if a couple is discordant. The practical issue is to what extent discordant couples actually do change their behavior as a consequence of a VCT intervention. There is an extensive literature on individual responses to VCT that finds that HIV-positive testers increase their condom use, while HIV-negative testers do not increase their condom use – see an earlier Meta analysis of 27 studies by Weinhardt et al (1999) and the more recent experiment using monetary incentives to get clients to obtain test results by Thornton (2007). However, the relevant evidence for our CBA framework is the response to

\[\text{For three villages in Malawi, Thornton (2007) found that when offered free testing in their homes, only 34\% of testers attended clinics to learn their results; but when they were offered a monetary incentive the percentage that sought their test results doubled. She found that the number of condoms that clients purchased on average was two condoms when given 30 cents and charged a price half of the going rate. She called this response “small”, presumably because 18 was the maximum number of condoms that people could have bought in her experiment. Only HIV-positive testers bought the condoms offered. There are two main problems with her interpretation of her VCT results. First, the number of condoms purchased was a function not only of the VCT services given, but also the price charged and the amount given to purchase the condoms in her experiment. If any of the determinants of condom purchases other than the VCT were different, the number of condoms purchased would also have been different. Second, buying 2 condoms is not necessarily a small response to being provided with VCT. At a price of 2 cents, buying 2 condoms means that 4 cents out of the 30 cents given was devoted to purchasing condoms, i.e., 13.3\% was spent. 13.3\% is a very large share of the additional income that was spent on condoms. This marginal share would be many times larger that the average propensity to consume condoms, especially if someone previously never bought condoms. Irrespective of how one interprets Thornton’s Malawi results, they have limited applicability to our CBA of VCT in Tanzania as we are working with voluntary counseling and testing, and not incentive driven testing, and we are, as explained in the text, interested in discordant couple’s behavior, not individual. In our base-line evaluation for VCT in Tanzania, we are}\]
VCT by discordant couples. This literature is much smaller, but when it comes to Africa, as for Ruanda in Allen et al. (1992) and Zaire in Kamenga et al. (1991), the results are uniform that discordant couples increased their condom use and, even more importantly, VCT services reduced the number of HIV infections.

It is in terms of securing a behavioral response that one can argue that this is where the counseling part of VCT comes into play. The aim is to convince those tested to change their behavior. In other words, it is because we include the costs of counseling together with the costs of testing when doing our CBA of VCT that we can expect VCT to be effective and there to be behavior change. Testing on its own cannot be relied on to be effective.

As for actual evidence of behavior change in the Tanzania context we can point to the VCT efficacy study for Tanzania, Kenya and Trinidad – see The Voluntary HIV-1 Counseling and Testing Efficacy Study Group (2002). Both males and females who were HIV positive were statistically more likely to reduce unprotected intercourse with their primary partners when assigned to VCT rather than just be given health information. As a check on our cost-benefit outcomes we also estimated empirically the number of cases averted. Using panel data for 20 regions in Tanzania over the five dealing with clients who were 10 times more likely to be HIV positive than the average, while in Malawi her sample had HIV prevalence rates half the average. Our sample was much more motivated to change their behavior than for the Malawi sample, so our CBA application of VCT in Tanzania is likely to fit in better with the models’ assumptions of effectiveness. Thornton’s work has most relevance for our long-run evaluation where we assumed that the average person would receive VCT services. These people are much less likely to be motivated to change their behavior upon testing. Hence we may have overestimated effectiveness in this case if the only way that we can ensure that the average person gets VCT is for him/her to receive a financial incentive.
year VCT period, we found that each person tested in the program led to somewhere between 3 and 6 fewer infections, a figure many times larger than the 0.2067 reduction in our base-line estimates. So it is unlikely that our estimates in tables 2 and 3 overstate the effectiveness of the VCT program for Tanzania.

Since our welfare criterion provides a general framework for evaluating VCT services, one is free to adapt the framework to accommodate special circumstances that may be of particular relevance in a given country. For example, say there is a concern that unprotected sex in situations where both members were infected could lead to more virulent strains of HIV being generated. One could treat this in the model as a case where \( p \) would rise by a specified amount and the value of lives saved would go up accordingly. If in a particular country couples with both persons infected did not undertake unprotected sex, then it would not only be discordant couples that would be counseled to change their behavior. The cost of this behavior change by the concordant positive couples would be the loss of the benefit of unprotected sex that each of them previously enjoyed (i.e., \( B_m + B_w \)). Since this would occur with probability \( p_m p_w \) the expected utility loss due to avoiding the rise in \( p \) would be: \( p_m p_w [B_m + B_w] \). But, this

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15 The estimation involved running a regression of the number of persons tested in a region on the number of female HIV infections among blood donors in a region, using as controls for each region the percentage positive in the VCT program, the percent of females enrolled in primary schools and the nominal GDP. There were 73 observations. The OLS estimate was –3.89, the random effects estimate was –5.66, and the fixed effects estimate was –6.68. The Hausman test pointed to the random effects coefficient being the more consistent estimator. In this equation, all coefficients were significant at least the 1% level and the R-squared for the equation was 44.57%.

16 The large empirical estimates of VCT effectiveness are not necessarily implausible give the fact that HIV intervention programs at the regional level in Tanzania have been found to exhibit large external effects. For example, increased female primary education enrollment rates led to large regional income effects, see Brent (2008a), and condoms provider benefits not just for the user but also for the partner, see Brent (2008b).
is exactly what is contained in equation (3c). So a concern with generating more virulent strains can be accommodated by bringing $U_c^3$ into the welfare change $\Delta U_c$ and not just relying on $U_c^1$ and as $U_c^2$ as in our analysis.

Similarly, although not mentioned explicitly, the stigma of being tested for HIV is a consideration that is already a part of the CBA framework. Not everyone in a VCT program would want to get tested because of the fear that they would be stigmatized (discriminated against) if they were found HIV positive.\textsuperscript{17} We allowed for this in our welfare criterion (13) by applying just the numbers tested $N^T$ to the benefits, while retaining all the numbers in the VCT program $N^{T+T'}$, whether they were tested or not, and applying that to the costs. The greater the extent of stigma in a country, or in a program, the greater would be the difference between $N^T$ and $N^{T+T'}$. Moreover, the greater the stigma, the more likely it would be that those currently in a VCT program would have a higher share that were HIV positive than the rest of the population. For countries then with greater stigma, the CBA results for evaluating existing programs, the base-line estimates, would be more relevant (with the high $p$ values) rather than the scaled up results which depend on probability values pertaining to the general population.

Apart from constructing a welfare criterion that includes the external effects on a partner, and high-lighting the foregone benefits of unprotected sex involved with

\textsuperscript{17} The effect of stigma depends on the prevalence rate and social circumstances. Thornton (2007) found for Malawi that a small financial incentive (less than a tenth of a day’s wage) was sufficient to overcome the adverse effect of stigma on getting tested. The individuals now had a public excuse to attend the results center as attendance was required in order to get the financial reward.
effective VCT programs and putting a monetary valuation on it for the first time, the
other main contribution of this paper has been to provide a way of thinking about how
the social outcomes for a scaled-up VCT program would differ from that of an existing
version. When VCT programs start to operate, it is the high-risk individuals who are
attracted first. In Tanzania around 15 percent of both sexes had ever had a test as of
2003/04.\(^{18}\) The percentage that test HIV positive is large in this group (around 70% in
Tanzania). In the long-run, when a larger share of the population gets tested, it is the
average risk person that enters the program and it is their risk probabilities that are
relevant (around 7% in Tanzania).

It was predictable that the existing program in Tanzania with the higher risk
individuals would indicate a larger number of discordant couples than under a scaled-up
program, and hence the number of projected lives saved would be greater (741 as
opposed to 233). But, what was rather surprising was that the social long-run desirability
of the scaled-up VCT program was not only greater than for the existing program, it was
almost three times larger. This was because the long-run foregone benefits of
unprotected sex were only 10 percent of those in the existing program. In fact, the
desirability of separate testing was so high that in the long-run, the differential between
separate testing and dual testing would disappear. So the policy conclusion that follows
from our application of cost-benefit analysis to VCT in Tanzania is that although the
existing program is marginally worthwhile, VCT should be greatly expanded throughout
Tanzania as future returns would be even higher for both separate and joint counseling

\(^{18}\) See THIS (2005, p51).
and testing. So VCT scaling-up, which has been already been approved in Tanzania on other grounds, is indeed justified on the basis of CBA.

Two aspects of the fact that we have built our framework on P&P’s analysis warrant further discussion. Firstly, we have adopted the assumption of voluntary expected utility maximization behavior by individuals. If coercion is involved then obviously our framework and evaluation does not apply. In particular, our effectiveness estimates would have to be greatly lowered if safe sex was not an option and, more importantly, the whole emphasis in the paper on the costs of foregoing the benefits of unprotected sex would be questionable if unprotected sex did not generate positive utility as assumed.

Secondly, P&P originated their work at a time when treatment in the form of Antiretroviral Therapy (ARVs) was not available.\textsuperscript{19} So we have also assumed that the main reason to get tested is to learn something that will be useful to prevent further HIV infections. If people now get tested in order to get ARVs, then this could affect the analysis. In our application to Tanzania for the period 1997-2001, ARVs were not much in evidence. So the P&P assumption behind getting tested seems relevant and our application valid. But, more generally, with ARVs in the mix, individual testing in order to get individual treatment would have to be added as a separate class for VCT

\textsuperscript{19} However, AZT was around and Philipson and Posner (1993) refer to the life prolonging and AIDS postponing benefits of this drug throughout their book.
evaluations.\textsuperscript{20} In so far as one is sticking with the sexual transmission framework and discussing the introduction of ARVs, it is clear that although the couples setting would still be fundamental to a social CBA, most parameter values would have to be recalibrated. ARVs lower the viral load so transmission rates would be different with and without ARVs. Also with life expectancies altered, the VSL amounts would have to be increased.

As an example of how the couples’ framework would require recalibration in the presence of ARVs, consider the effectiveness estimate of VCT. In our analysis this was determined by the probability that a couple would be discordant as given by $p$ $(1-p)$. In Tanzania for the period 1997-2001, without ARVs, $p$ was 0.708 and $p$ $(1-p)$ was therefore 0.2067. Since then, there has been an enormous expansion in VCT services. Numbers being tested rose from 7,473 in 2001 (the last year of our study period) to 77,956 in 2002, to 83,205 in 2003, and 122,584 in 2004. As expected, as the program reached more of the general population, $p$ fell to around 0.2 in 2002 and 2003, and $p$ $(1-p)$ dropped to 0.16. However, in 2004 $p$ jumped up drastically to 0.4 making effectiveness 0.24, even higher than for our baseline period. One of the reasons why there was an increase in the numbers tested in 2004 was, according to the Ministry of Health (2005, p 53), the “introduction of VCT services in the country”. The increased number of tests in 2004 was therefore bound to increase the share who was HIV

\textsuperscript{20} Philipson and Posner (1993, p106) recognized that apart from getting treatment, there were a large number of other motives for testing than sexual strategies and that not all of them could be covered by one umbrella evaluation framework. Of relevance for this study is the fact that we are not including fertility issues. So there is no cost in our model to a discordant couple being encouraged to use condoms from VCT in terms of forgoing the benefit of having children, and nor is there a benefit in our model for the same couple from avoiding unwanted pregnancies by now using condoms.
positive as these would be the ones who get the ARVs. The long-run effectiveness and net-benefits would not be affected as eventually the general population would be reached. But the short-run evaluations of VCT program would be altered by the availability of ARVs. Of course, if the reason people get tested is to avoid transmission to themselves, and their partners, and to receive ARVs if they are positive, then one needs to combine the outcomes of a CBA of VCT services, as outlined in this paper, with the outcomes of a CBA of ARVs, as outlined elsewhere.\textsuperscript{21}

Acknowledgements

This paper was started with the financial assistance provided by the Fulbright Research award for 2003. It was part of the project on the Cost-Benefit Analysis of HIV-AIDS interventions programs in Tanzania carried out when the author was a visiting Professor in the Department of Economics at the University of Dar Es Salaam in Tanzania. I particularly wish to thank Dr. Longinus Rutasitara for all his support during my stay at the University. The paper benefited greatly from conversations with Markus Haacker who helped me understand and apply his work on trying to measure the welfare effects of HIV/AIDS. Any remaining errors are my own.

Appendix A: The Four Cases for Dual Testing and Proposition 1

Here we explain the derivation of equation (4). In the text we point out that VCT is beneficial only if one learns something from the testing and then there are changes in behavior. We need to examine what is learned and what will be changed. With dual testing $p_{m}$ and $p_{w}$ are ether 0 or 1, so there are four possible cases.

\textsuperscript{21} See Brent (2009) who found that ARVs were worthwhile using a CBA that priced a Disability Adjusted Life Year (DALY) using the implicit preferences behind the Global Fund for AIDS, Tuberculosis and Malaria grant decisions.
If the man tests positive and the female tests negative, we have $p_m = 1$ and $p_w = 0$. For these probabilities in equation (2), the outcome would be: $B_m + B_w - C_w$. If there were no change in behavior, the woman would get HIV and the man would not (because he already has it). The joint probability of this outcome occurring ex ante would be $p_m (1 - p_w)$, so the expected utility for the couple testing in this first case is:

$$(3a) \quad U_{c1} = p_m (1 - p_w) \left[ B_m + B_w - C_w \right]$$

The case where the man tests negative and the woman tests positive ($p_m = 0$ and $p_w = 1$) is symmetric to the first case. The outcome is: $B_m + B_w - C_m$, the ex ante joint probability is $p_w (1 - p_m)$, and the expected utility for the couple testing in this second case is:

$$(3b) \quad U_{c2} = p_w (1 - p_m) \left[ B_m + B_w - C_m \right]$$

The first two cases involved discordant couples, where one partner was positive and the other was negative. The remaining two cases involve couples with partners that are either both positive or both negative. In either case there is no chance of getting infected and thus no HIV costs involved with risky sex. When both are tested positive, $p_m = p_w = 1$ is substituted into equation (2) and this produces the outcome: $B_m + B_w$. The ex ante joint probability of this outcome occurring is $p_m p_w$. The expected couple utility is therefore:
(3c) $U_{c3} = p_m p_w [B_m + B_w]$

Finally, when both are tested negative, i.e., $p_m = p_w = 0$, the outcome is again: $B_m + B_w$, the joint probability for this outcome is $(1 - p_m)(1 - p_w)$ and the expected couple utility is:

(3d) $U_{c4} = (1 - p_m)(1 - p_w)[B_m + B_w]$

As: $U_c = U_{c1} + U_{c2} + U_{c3} + U_{c4}$, the cost-benefit criterion given by equation (2) can be decomposed into the four cases given in (3a) to (3d).

Once testing has taken place, self-interest ensures that the outcomes in the first two cases would not materialize. P&P take as an axiom that no one would knowingly have unprotected sex if they knew for certain that their partner was HIV positive and they were not. Strictly, this implies only that $B_w - C_w < 0$ in case 1 and $B_m - C_m < 0$ in case 2. But, in a voluntary sex context assumed by P&P, a negative utility result for one partner ensures that the risky sex act does not take place. So both square bracket terms in equations (3a) and (3b) would become zero because risky sex would now cease for discordant couples. Cases 3 and 4 would not require any behavior change with or without testing as no HIV transmission takes place.

To summarize, equations (3a) and (3b), with a change in sign, specify the net benefits of dual testing because it is these outcomes that would be expected to be avoided by carrying out the tests. Formally, we define the change in couple utility $\Delta U_c$
as the difference between expected couple utility before the testing with no behavior change \( U_{cT}' = U_{c1} + U_{c2} + U_{c3} + U_{c4} \) and expected couple utility after the testing with no behavior change \( U_{cT} = U_{c3} + U_{c4} \) net of the costs of testing (which is twice the cost \( K \) of a single test in the dual text context):

\[
\Delta U_c = U_{cT} - U_{cT}' - 2K = -U_{c1} - U_{c2} - 2K,
\]

or

\[(A.1) \quad \Delta U_c = p_m (1 - p_w) [C_w - B_m - B_w] + p_w (1 - p_m) [C_m - B_m - B_w] - 2K\]

Equation \((A.1)\) can be reduced to its key components to form:

\[(4) \quad \Delta U_c = p_m (1 - p_w) C_w + p_w (1 - p_m) C_m - (p_m + p_w - 2p_m p_w) [B_m + B_w] - 2K\]

**Appendix B: The Two Cases for Single Testing and Proposition 2**

Here we explain the derivation of equation (7). Consider the situation where there is a single test, say the male. Let us first see how the male would evaluate testing and then compare that with the social test. With single testing there are only two cases to analyze and one testing cost to incur.

Since the male evaluates his HIV test using the utility function specified in equation (1): \( U_m = B_m - p_w (1 - p_m) C_m \), should he be found HIV positive his utility
outcome would be raised to $B_m$ and this would have an ex ante probability of $p_m$. The expected utility for the male from risky sex would simply be:

\[(5a) \quad U_m^1 = p_m [B_m]\]

There is absolutely no cost for the male now to continue with risky sex. Should he be found HIV negative, the outcome would be lowered to $B_m - p_w C_m$, with an ex ante probability of $(1 - p_m)$, making the expected utility:

\[(5b) \quad U_m^2 = (1 - p_m) [B_m - p_w C_m]\]

Risky sex is more likely to make the male infected and this decreases his utility from it.

Equations (5a) and (5b) ignore the utility effects on the woman. So we will use the social criterion given by equation (2) to analyze the two possible test outcomes for males. The couple’s counterpart to equation (5a) with $p_m = 1$ is:

\[(6a) \quad U_c^1 = p_m [B_m + B_w - (1 - p_w) C_w]\]

and the social counterpart to equation (5b) with $p_m = 0$ is:

\[(6b) \quad U_c^2 = (1 - p_m) [B_m + B_w - p_w C_m]\]
A comparison can be made between equations (5a) and (6a), and between equations (5b) and (6b). With a male test showing \( p_m = 1 \), ex ante the man’s expected utility \( U_{m1} \) is excluding \( p_m [ B_w - (1 - p_w) C_w ] \) from the calculations from the social point of view. Since only the male is getting tested, we do not know \( 1 - p_w \) in this expression. So unlike the dual test, where \( B_w - C_w \) is in the square brackets of equation (3a), we have instead \( B_w - (1 - p_w) C_w \). We cannot be sure that the female will get infected. If she were already infected then the infected male would not transmit this to the female. Nonetheless, we are going to assume that the woman would not knowingly have risky sex with an infected man unless she knew for certain that she was infected. This new axiom would be sufficient to ensure that equation (6a) would involve behavior change after the test results were revealed to the male, provided the results were also made known to the partner.

With a male test showing \( p_m = 0 \), there is very little difference between (5b) and equation (6b). Ex ante the man’s expected utility \( U_{m1} \) is excluding \( (1 - p_m) B_w \) from the calculations. Given that the man continues with risky sex, there is no behavior change and this utility gain will not be lost.

For single male testing we then have the result that equation (6a), with a change in sign, specifies the net benefits as it is this outcome that would be expected to be avoided by carrying out the tests. The change in couple utility \( \Delta U_c \) is again defined as the difference between expected couple utility before the testing with no behavior
change \( U_{c}^{T} = U_{c}^{1} + U_{c}^{2} \) and expected couple utility after the testing with no behavior change \( U_{c}^{T} = U_{c}^{2} \) net of the costs of the single test:

\[
\Delta U_{c} = U_{c}^{T} - U_{c}^{T'} - K = -U_{c}^{1} - K, \quad \text{or}
\]

\[
(7) \quad \Delta U_{c} = p_m (1 - p_w) C_w - p_m [B_m + B_w] - K
\]

**Appendix C: Altruism and Proposition 3.**

In terms of the current formulation, altruism basically means that there is a multiplier effect. If the original effect is not positive then multiplying the effect will not change the direction of the effect. To see this, let us use stars * to relate to utility functions with altruism:

\[
(12) \quad U_{m}^{*} = U_{m} + \alpha_{m} U_{w} \quad \text{and} \quad U_{w}^{*} = U_{w} + \alpha_{w} U_{m}
\]

where \( \alpha_{m} \) is the man's weighting of the woman's utility and \( \alpha_{w} \) is the woman's weighting of the man's utility. The couple's joint utility is:

\[
(13) \quad U_{c}^{*} = U_{m}^{*} + U_{w}^{*} = (1 + \alpha_{w}) U_{m} + (1 + \alpha_{m}) U_{w}
\]

Let there be complete altruism: \( \alpha_{m} = \alpha_{w} = 1 \). Then equation (13) becomes:
(C.1) \[ U_c^* = (1 + 1) U_m + (1 + 1) U_w = 2(U_m + U_w). \]

Complete altruism leads to double counting and not the couple’s utility function.

To avoid double counting, one can deal with a single individual as in P&P, say the male, and introduce altruism just for the female partner in his utility function: \( \alpha_m = 1, \alpha_w = 0. \) In this case of asymmetric altruism, equation (13) would be:

(C.2) \[ U_m^* = U_m + U_w \]

Equation (C.2) is the same as the sum of the two separate utility functions \( U_c = U_m + U_w \) that underlay the construction of equation (2), which implies \( U_m^* = U_c. \) So single testing of the male would internalize the externality. But, this does require that \( \alpha_w = 0, \) which means that in equation (12) we have:

(C.3) \[ U_w^* = U_w \]

That is, the female’s utility function would not equal \( U_c \) and so she would not internalize the externality. The argument works exactly in reverse if the female has the asymmetric altruism: \( \alpha_m = 0, \alpha_w = 1. \) Now the female’s single testing would internalize the externality while the man’s would not.
For equation (13) to ignore completely the utility of one of the partners, i.e., there be no altruism at all, one would need either: \( U_c^* = U_m \), or \( U_c^* = U_w \). To lead to this result, either \( \alpha_m = -1 \) or \( \alpha_m = -1 \). Thus, \( \alpha_m = \alpha_w = 0 \) does not imply no altruism. If we substitute \( \alpha_m = \alpha_w = 0 \) into equation (13) we get:

\[
(C.4) \quad U_c^* = U_m + U_w
\]

Our use of the couple’s formulation: \( U_c = U_m + U_w \) is equivalent to adopting (C.4). So we are just using the special case of equation (13) where \( \alpha_m = \alpha_w = 0 \) and this simply means that our couple’s formulation of utility does already capture altruism in some form.

References


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