

**“Conditional scholarships” for HIV/AIDS health workers:
educating and retaining the workforce to provide antiretroviral
treatment in sub-Saharan Africa**

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Abstract

Without large increases in the number of health workers to treat HIV/AIDS (HAHW) many countries in sub-Saharan Africa (SSA) will be unable to achieve universal coverage with antiretroviral treatment (ART), leading to large numbers of potentially avoidable deaths among people living with HIV/AIDS. We conduct a cost-benefit analysis of a scholarship for health care education that is conditional on the recipient entering into a contract to work for a number of years after graduation delivering ART in SSA. Such a scholarship could address two of the main reasons for the low numbers of health workers in SSA: low education rates and high emigration rates. We use Markov Monte Carlo microsimulation to estimate the expected net present value (eNPV) of “conditional scholarships” in SSA. We find that under a wide range of plausible assumptions the scholarships are highly eNPV-positive. “Conditional scholarships” for a team of health workers sufficient to provide ART for 500 patients have an eNPV of 1.23 million year-2000 US dollars, assuming that the scholarship recipients are in addition to the health workers who would have been educated without scholarships and that the scholarships reduce annual HAHW emigration probabilities from 15% to 5% for five years. The contribution to eNPV of the effect of the scholarships on education rates is larger than the contribution of their effect on migration rates. Policy makers should consider implementing “conditional scholarship” for HAHW, especially in countries where health worker education capacity is currently underutilized or can be rapidly expanded.

Introduction

The number of people in developing countries who receive antiretroviral treatment (ART) has grown rapidly in recent years – in SSA from less than 300,000 by the end of 2004 to more than 1 million by the end of 2006 (UNAIDS/WHO, 2006). Yet current ART coverage falls far short of ART need. In 2006, an estimated 4.6 million people in SSA needed ART, more than four times the number of people on treatment (UNAIDS/WHO, 2007). The unmet need for ART means the loss of many lives that could have been saved (Braitstein, Brinkhof, Dabis, Schechter, Boulle, Miotti et al., 2006).

One of the main constraints in scaling up ART is human resources (IOM, 2007; MSF, 2007). Based on a recent review of the numbers of different types of health workers needed to provide ART to a fixed number of patients in developing countries (Hirschhorn, Oguda, Fullem, Dreesch, & Wilson, 2006) we estimate that in order to treat the approximately 3.6 million people in SSA (UNAIDS/WHO, 2007) who in December 2006 needed ART, but did not receive it, the stock of health workers in SSA would have had to be increased by 3,600 to 7,200 doctors, 7,200 to 25,200 nurses, and 3,600 to 10,800 pharmacists.

There are two main reasons for the shortage of health workers to treat HIV/AIDS (HAHW) in SSA (JLI, 2004; WHO, 2006). First, education rates are too low to produce the number of health workers needed to deliver ART. According to one estimate, in SSA each year only 5,100 doctors graduate from medical school

(Eckhert, 2002). Second, of the small numbers of health workers educated in SSA large proportions emigrate. For instance, it has been estimated that 20,000 health workers migrate each year from Africa to developed countries (WHO, 2004).

“Conditional scholarships”

Most interventions that have been proposed or implemented to address health worker shortages focus on decreasing migration by addressing one of its causes or enabling factors (Arango, 2000) – “push factors” in source countries, such as low salaries, unattractive career paths and poor working conditions, or employment opportunities for family members, on the one hand, (Dovlo, 2007) and admission policies in recipient countries, on the other hand (Stilwell, Diallo, Zurn, Dal Poz, Adams, & Buchan, 2003). We focus here on one particular policy that could potentially address both of the main reasons for HRHA shortages in SSA: scholarships for health care education given to qualified candidates with the condition that they enter into a contract to work for a number of years after graduation delivering ART in SSA (“conditional scholarships”). First, the “scholarship” could increase education rates by enabling the health care education of secondary school graduates who would otherwise not have the means to finance such an education (the education effect). Second, the “condition” could delay emigration by decreasing emigration rates during the time period when scholarship recipients fulfill their obligation to work in a sub-Saharan country (the migration effect).

For “conditional scholarships” to be effective the following assumptions must be true. First, there are qualified candidates in developing countries who desire a health care education but cannot obtain financing for such studies because of market imperfections in the supply of education loans (Barr, 2004). There is evidence that secondary school graduates in SSA do indeed forego a health care education because they lack the financial means to pay for tuition, fees, living expenses or learning materials (Colborn, 1991, 1992; IRIN Humanitarian News and Analysis, 2006).

Second, there are qualified candidates in developing countries who desire a health care education and do have access to sources of finance for such an education (e.g. loans from the extended family or bank loans) but find the “conditional scholarship” the most attractive amongst all available funding options. For instance, students may prefer a “conditional scholarship” to a bank loan, because unlike the latter the former does not carry the risk of bankruptcy, if the recipient cannot meet interest or redemption payments.

If either of the above two assumptions is met, the “conditional scholarships” will decrease health worker emigration rates, as long as some of the qualified candidates who are willing to participate in the “conditional scholarships” program are accepted into health care education and emigration rates of scholarship recipients are on average lower than the emigration rates of health workers who

have not received a “conditional scholarship”. In order for “conditional scholarships” to increase health worker education rates, the first assumption must be met and health care education capacity must not be fully utilized in the period prior to the implementation of the “conditional scholarship” program.

In the following we will investigate whether “conditional scholarships” would be socially worthwhile investments by estimating their expected social net present value (eNPV) given different assumptions about their effectiveness in increasing education rates and decreasing emigration rates.

Methods

Model description

We conduct a cost-benefit analysis of “conditional scholarships” for HAHW, estimating the eNPV of the scholarship in Markov Monte Carlo microsimulation. Net present value (NPV) is the sum of the benefits of a project, such as the scholarship program, accruing in different periods of time minus the sum of its costs, when all benefits and costs are discounted to their value in the present. eNPV is the weighted average of the NPV over all possible outcomes of a project, where the weights are the probabilities of the different outcomes to occur. Markov models divide a target population (here: of health workers) into a series of mutually exclusive states (here: of health worker effectiveness). Transitions between these Markov states are assigned probabilities and the model's predictions are evaluated over a series of cycles (Sonnenberg & Beck,

1993). Markov models are well suited for the question at hand because they allow different states of HAHW effectiveness with different costs and benefits at different times, and can easily incorporate discounting to calculate present values of future states (Hunink, Glasziou, Siegel, Weeks, Pliskin, Elstein et al., 2001). Markov models can be evaluated deterministically by cohort simulation or stochastically by Monte Carlo microsimulation. If a large number of individuals are simulated in microsimulation, the mean expected values of different microsimulations will be approximately the same and will closely approximate the result of the cohort simulation. However, microsimulation has the advantage over cohort simulation that it yields an approximate distribution of eNPV in addition to its mean thus enabling assessment of uncertainty in the calculations due to individual heterogeneity (Law & Kelton, 2000; Weinstein, 2006).

In providing ART, health workers reduce mortality among HIV-positive people and induce costs (salaries and costs of drugs). Mortality reduction and treatment costs depend on the type and time of ART: In developing countries, the survival probability during the first year on ART is lower than the survival probability during the second year on ART or during later years, because considerable proportions of patients in ART programs in developing countries start treatment in advanced stages of HIV disease when recovery may no longer be possible (Braitstein et al., 2006). In addition, second-line therapy is more expensive than first-line therapy. To capture these differences, we distinguish between the following Markov states in the model: first-line ART in the first year of treatment

(ART1); first-line ART in the second or a later year of treatment (ART2); second-line ART (ART3); and an absorbing state (Exit) which HAHW enter if they die or emigrate.

The unit of our analyses is a “minimum team” of health workers, consisting of nurses, treatment counselors, doctors, and pharmacists. We define a minimum team as the team with the smallest number of members in which none of the four categories of HAHW has less than one member. We chose this particular scale of minimum team instead of a fraction of it, because health workers are obviously not divisible in death or emigration. However, the scale of the health worker team is not central to our results. The mean eNPV of “conditional scholarships” for any fraction (or multiple) of one minimum team – e.g. for one five-hundredth, i.e. the fraction of a minimum team sufficient to treat one patient) – can be computed by multiplying the eNPV of the scholarships for a minimum team by the fraction (or multiple).

It is always the entire minimum team that moves from one Markov state to the next. While the composition of the minimum team does not change, its effectiveness in reducing mortality and the cost it induces in one particular cycle of the Markov model depends on the type of patients it treats. We assume that in its first year of service the minimum team treats only patients who are newly initiated on ART. This assumption closely resembles the situation in many developing countries with large unmet ART need (Braitstein et al., 2006). After

having completed the first year (or any future year) in ART1, the entire minimum team either leaves the required service prematurely (because of emigration or deaths of members) or continues its service. If the team continues its service, the Markov state it will transition into depends on the treatment outcome of its patients. The team will transition to ART2 if its patients survive (i.e. to a Markov state in which the same costs are incurred per patient as in ART1, but patients face better survival probabilities), to ART1 if its patients die or are lost to follow-up, or to ART3 if its patients need to switch from first-line to second-line therapy (i.e. to a Markov state in which higher costs are incurred per patient, and patients face the same survival probabilities as in ART2).

We fix the ratio of nurses to counselors to doctors to pharmacists within the minimum team at 3:10:1:1 based on Hirschhorn and colleagues (Hirschhorn et al., 2006). In the base case, a minimum team is assumed to be able to provide treatment to 500 patients. Death is an important cause of health worker loss in SSA, especially in countries with high HIV prevalence, where the majority of people who are currently in need of ART live (WHO, 2006). In order to take the effect of mortality on the value of “conditional scholarships” into account, we model the survival of health workers by deriving sex and age-specific probabilities of dying after each Markov cycle from the *INDEPTH Life Tables for sub-Saharan Africa* for countries in “Eastern and Southern Africa with adult HIV prevalence typically above 10%” (INDEPTH, 2004). We assume that the health workers are 30 years of age when they start working in ART programs and that

half of all workers are female. The cycle length for the model is set to one year. In each cycle, the minimum team induces benefits (the monetary value of the life-years saved because of ART) and costs depending on its current Markov state.

We adopt a modified societal perspective, in that the indirect costs of antiretroviral treatment that accrue to patients (time and travel costs) are not included in the analyses. Further, we do not take into account reductions in health spending that come about because patients on ART fall ill less often and less severely than people who need ART but do not receive it. In the base case, future costs and benefits were discounted at 3% per year to allow for social time preference, as recommended by the US Panel on Cost-Effectiveness in Health and Medicine (Siegel, Torrance, Russell, Luce, Weinstein, & Gold, 1997) and as is commonly done in priority setting for health in developing countries (Goldie, Yazdanpanah, Losina, Weinstein, Anglaret, Walensky et al., 2006; Murray & Lopez, 1996). In sensitivity analyses, we varied the discount rate between 2% and 8%. All costs and benefits were measured in year-2000 US dollars. Unless otherwise indicated, all dollar amounts in the text below are expressed in year-2000 US dollars. The model was implemented in TreeAge Pro Suite 2007 (TreeAge Software Inc., Williamstown, MA, USA).

Simulated scenarios

In order to understand the specific contribution of the two possible effects of the “conditional scholarships” on eNPV – the education effect and the migration

effect –, we examine separately three types of scenarios: first, the only effect of the scholarships is to increase HAHW education rates; second, the scholarships increase HAHW education rates and decrease HAHW emigration rates; third, the only effect of the scholarships is to decrease HAHW emigration rates.

A new dataset published by the *World Bank International Migration and Development Program* contains doctor emigration rates from 46 sub-Saharan African countries for a total of 642 country-years (Docquier & Bhargava, 2006). When the number of doctors in each country in each year of observation is used as weighting factor and the annual rates are converted to annual probabilities, the weighted average annual probability of doctor emigration across the 642 country-years is 13.4%. In our model, we use values for the annual probability of HAHW emigration in the absence of “conditional scholarships” that are slightly higher (15%) or slightly lower (12%) than this average. Further, in scenarios with an effect of the scholarships on emigration, we vary the emigration effect (a reduction to either 5% or 3% per year) and the length of the service commitment during which the effect is assumed to persist (3, 5, or 7 years) (Table 2).

Estimates for model variables

Estimates for model variables, as derived from published studies, are shown in Table 1. The baseline costs of the “conditional scholarships” for physicians and nurses are based on estimates of the costs of medical and nursing school in

Malawi in 2006 (Muula, Panulo, & Maseko, 2006) and the cost of medical school in Kenya in 2005 (Kirigia, Gbary, Muthuri, Nyoni, & Seddoh, 2006), both of which include tuition and costs of living during the time of education. We did not have measured estimates from African countries of the costs of education of a pharmacist. We derived the costs of educating a pharmacist by assuming that the annual costs of training a pharmacist are equal to the annual cost of training a physician, but that the pharmacist requires five instead of six years of training. To estimate the cost of education of a treatment counselor, we took the cost of 14-day courses for counselors in South Africa in 2007 (including travel and food expenditures) and assumed that it takes six months of training to become a counselor in Africa. Both the estimates of cost per time and the length of training time are likely to be high in comparison to their true values across different countries in SSA, leading to conservative estimates of eNPV of the “conditional scholarships”.

In univariate sensitivity analysis we vary the total costs of the “conditional scholarships” for one minimum team up to a maximum (725,000 dollars) that would cover tuition and living expenses, if the team were educated in the United States (Morrison, 2005). Other costs included in the model are doctor, nurse, pharmacist, and counselor salaries. In some settings, contribution of time from some other types of health workers may be needed in a minimum team to deliver ART (such as lab technicians, drivers and data managers). Our sensitivity analyses of scholarship costs and health worker salaries can be used to assess

in how far such additional health workers would affect the value of the “conditional scholarships”.

Treatment costs comprise of costs of first- and second-line ART, cotrimoxazole prophylaxis, and CD4 counts. We use weighted averages of the prices of antiretroviral drugs across all sub-Saharan countries for which price information was available in the *WHO Global Price Reporting Mechanism (GPRM)* in June 2007 (WHO, 2007a). As weighting factors we use the number of people in each sub-Saharan country who according to UNAIDS/WHO needed ART in December 2006 but did not receive it (UNAIDS/WHO, 2007). Information on both drug price and people with unmet ART need was available for 35, 34, 32, 29, 23, 21, 19, and 16 sub-Saharan countries for nevirapine (NVP), efavirenz (EFV), lamivudine (3TC), stavudine (d4T), abacavir (ABC), lopinavir/ritonavir (LPV/r), didanosine (ddI), and tenofovir disoproxil fumarate (TDF), respectively. In the base case, we assume that first-line ART consists of d4T, 3TC and NVP, which are offered as first-line ART in many sub-Saharan countries (WHO, 2007b). We calculate weighted average prices for three alternative first-line regimens (d4T, 3TC and EFV; zidovudine (AZT), 3TC and NVP; AZT, 3TC and EFV) and vary the price of first-line therapy in univariate sensitivity analysis, using the weighted average price of the most expensive of the four first-line ART (AZT, 3TC and EFV) as the maximum. The alternative first-line regimens include two common types of single-drug substitution due to ART toxicity (i.e. EFV instead of NPV and AZT instead of d4T).

Similarly, we assume in the base case that second-line ART in SSA consists of ddl, 3TC and LPV/r (WHO, 2007b), but calculate weighted average prices for three alternative regimens (ddl, ABC and LPV/r; TDF, ABC and LPV/r; TDF, 3TC and LPV/r) to estimate the eNPV of the “conditional scholarships” if the least and the most expensive of the four regimens are used as second-line ART (Table 3a).

Estimates of mortality among people with CD4 count below 200 who do not receive ART are taken from a study in South Africa (Badri, Lawn, & Wood, 2006), and estimates of mortality among people with CD4 count below 200 at initiation of ART in the first and subsequent years of treatment are based on a 2006 review of 18 ART programs in low-income countries (Braitstein et al., 2006). Mortality among patients who are switched from first- to second-line therapy because of treatment failure are assumed to be the same as those on first-line therapy in the second or later years of treatment (Pujades, Calmy, O'Brien, Humblet, & MSF HIV/AIDS working group, 2007).

The dominant benefit of an ART program is the reduction in mortality as a result of treatment (Cameron, Gibson, Helmers, Lim, Tressler, & Vaddanak, 2006). To value this benefit an estimate of the monetary value of a statistical life year (VSLY) is needed (Johansson, 2002). No estimate of VSLY in Africa has been published. In our baseline estimation, we thus follow the convention suggested

by the 2001 *WHO Commission on Macroeconomics and Health* to value a statistical life year at three times per-capita gross domestic product (GDP). A number of recent studies both in developed and developing countries adopt this convention (Cutler & Richardson, 1997; Murray, Lauer, & Hutubessy, 2003; Philipson & Soares, 2001). We use the weighted average of per-capita GDP across sub-Saharan African countries (World Bank, 2007), with the numbers of patients who needed but did not receive ART in December 2006 as weighting factors (UNAIDS/WHO, 2007).

< Table 1 >

Results

Scenario analysis

Table 2 shows mean eNPVs (and 95% confidence intervals) of “conditional scholarships” for one minimum team of HAHW in 26 scenarios. Using 10,000 microsimulation trials, all 26 scenarios yield large positive eNPV estimates. The mean eNPVs of the scenarios in which the “conditional scholarships” increase education output of HAHW and decrease emigration (1.12 to 1.61 million dollars) are significantly higher than the mean eNPVs of the scenarios in which the scholarships only increase education output (0.80 and 0.95 million dollars). In turn, the mean eNPVs of the two scenarios in which the scholarships only affect education output is significantly higher than the mean eNPVs of any of the scenarios in which the “conditional scholarships” only reduce HAHW emigration

probabilities (0.15 to 0.56 million dollars). As must necessarily be the case in valid models, *ceteris paribus* all scenarios with shorter service commitments have lower mean eNPV than scenarios with longer commitments, and all scenarios with a larger reduction in emigration probabilities due to the scholarships have higher mean eNPV than scenarios with smaller reductions.

< Table 2 >

Sensitivity analysis

Figure 1 shows how eNPV estimates vary with changes in selected variables from the base case (i.e. when it is assumed that the “conditional scholarships” increase education output and decrease the annual probability of emigration from 15% to 5% during a five-year service commitment, and all variables are set to their base-case values as shown in Table 1). The selected variables cause the largest changes in eNPV amongst all variables in the model, when each individual variable is varied between its minimum and maximum value (Figure 1). The results were most strongly affected by variations in the number of patients treated by one minimum HAHW team, the VSLY and the costs of first-line ART. When individual variables are varied within plausible bounds (Table 1) suggested by the literature (Bertozzi, Gutierrez, Opuni, Walker, & Schwartlander, 2004; Coetzee, Hildebrand, Boule, Maartens, Louis, Labatala et al., 2004; Ferradini, Jeannin, Pinoges, Izopet, Odhiambo, Mankhambo et al., 2006; Gutierrez, Johns, Adam, Bertozzi, Edejer, Greener et al., 2004; Lawn, Myer, Bekker, & Wood,

2006; MSF, 2006; Murray et al., 2003; Yazdanpanah, Losina, Anglaret, Goldie, Walensky, Weinstein et al., 2005), eNPV never falls below 0.48 million dollars. The VSLY would need to be less than 1400 dollars in order for mean eNPV to be negative, when all other variables are set to their base-case values.

< Figure 1 >

Discussion

Our study is the first cost-benefit analysis of “conditional scholarship” programs for health workers. We find that “conditional scholarships” that pay for a health care education in return for a commitment to serve for a few years in an ART program in SSA are highly cost-beneficial under a wide range of plausible assumptions. This finding is by no means a foregone conclusion. For one, a substantial proportion of the costs of the program – the scholarship payments – accrue before the benefits from the work of its beneficiaries are obtained; discounting to allow for social time preference will increase the nominal value of the scholarship payments relative to the benefits. In addition, the average costs of ART are likely to increase over time, because the proportion of patients needing the more expensive second-line treatment increases with time. Moreover, the benefits of the scholarships will not reach their potential maximum value, as some health workers who have received the scholarship payments do not complete their obligated service because they emigrate or die.

Our model allows us to estimate the size of the social value of “conditional scholarships”. For instance, assuming that the scholarship recipients are in addition to the health workers who would have been educated without scholarships and that the scholarships reduce annual HAHW emigration probabilities from 15% to 5% for five years, we find that “conditional scholarships” for a team of health workers sufficient to provide ART for 500 patients have an eNPV of 1.23 million year-2000 US dollars. Any investment with positive eNPV should be implemented because it increase social well-being, However, policy makers may face budget constraints, which force them to select amongst different eNPV-positive projects. In this situation, the absolute size of the net benefit that can be obtained from investments may serve as an important decision criterion.

In this regard, two findings of ours sensitivity analyses may be important. First, the overall result that “conditional scholarships” are highly cost-beneficial is robust to changes in the values of individual model parameters, increasing the level of certainty that the “conditional scholarships” for HAHW will indeed be cost-beneficial, if implemented under some specific real-life conditions. Second, the value of “conditional scholarships” is relatively sensitive to changes in parameters that may be influenced by policy makers (drug prices, salary levels or scholarship costs) and health workers (the number of patients treated by one minimum team), highlighting that implementation decisions are likely to affect the social value of the scholarships.

The base-case assumption that one minimum team can provide ART for 500 patients is likely to be a conservative estimate. First, the study by Hirschhorn and colleagues, from which we take our base-case estimate, evaluates ART programs in their starting phases (Hirschhorn et al., 2006). As programs mature, they may become technically more efficient, increasing the number of patients that one minimum team can treat. Moreover, if ART is not available, the health status of HIV-positive people will deteriorate beyond disease stages in which treatment would normally begin. In their starting phases, ART programs will thus need more health workers per patient than in more mature stages. Second, if instead of our base-case estimate we took the lower bounds of the ranges of the numbers of health workers needed per ART patient from the study by Hirschhorn and colleagues, the health workers in our base-case minimum team could treat larger numbers of patients. According to the lower-bound estimates, 1 physician and 1 pharmacist are required to treat 1,000 patients, while 3 nurses could provide care for 1,500 patients.

However, it is also possible that as ART programs mature the number of health workers needed to treat 500 patients will increase, because ART adherence decreases with time on ART, requiring intensified counseling, or because the frequency of clinical events that require comparatively time-consuming interventions increases (such as treatment failures) (Bärnighausen, 2007).

Future evaluations of ART programs in SSA will show whether a minimum team

in a more mature programs can provide ART to fewer or more patients than a team of the same size in a recently started ART program. Our results suggest that even if the number of patients treated by one minimum team decreased over time, it is likely that the “conditional scholarship” programs would nevertheless remain cost-beneficial.

Either of the two possible effects of the “conditional scholarships” – the education effect and the migration effect – is sufficient on its own to make the scholarships a socially desirable investment. However, the social value of the education effect is larger than the value of the migration effect. In the short-term, the value of the “conditional scholarships” will thus be higher in countries with unutilized education capacity than in countries where education capacity is fully utilized. However, in the latter set of countries, the scholarships may increase the demand for health care education because some people who were previously willing but not able to pay for health education are now able to pay. In countries with substantial private health care education markets (Verspoor, Mattimir, & Watt, 2001) this increase in demand should lead to an increase in education supply through the price mechanism. In countries that currently do not have private education markets, governments could decide to increase public sector education capacity. Alternatively, governments in such countries could pass legislation legalizing private health care education institutions, while limiting their own role to accreditation and quality control (Cueto, Burch, Adnan, Afolabi, Ismail, Jafri et al., 2006).

In our model, we assume that mortality in the first year on ART is higher than in subsequent years. This mortality differential is not due to differences in ART effectiveness but to differences in the composition of ART patient cohorts over time. The evidence on mortality on ART from developing countries comes from programs in the first few years of their existence. Without ART HIV takes its natural course with continuously weakening immune functioning. Newly initiated ART patients from populations without previous access to ART are thus likely sicker and face worse prognoses than newly initiated patients from populations that have had access to ART for an extended period of time. As ART programs mature it is likely that the health status of newly enrolled patients will improve, possibly eliminating the mortality differential between the first and subsequent years on ART. This change would increase the effect of health workers on the survival of patients in need of ART and thus increase the eNPV of the “conditional scholarships”.

VSLY

We follow the suggestion of the 2001 *WHO Commission on Macroeconomics and Health* to value a life year at three times per-capita GDP (CMH, 2001). The *Commission* states that “[t]he economics literature on the value of life has a very strong and consistent conclusion: the value of an extra year of healthy life – as a result of successfully treating a disease, for example – is worth considerably more than the extra market income that will be earned in the year”. The specific

value of three times per-capita GDP “reflects the value of leisure time in addition to market consumption, the pure longevity effect, and the pain and suffering associated with disease” (CMH, 2001). Our base-case valuation of a statistical life year thus takes into account value derived from different sources of an individual’s well-being, but does not include the value of an individual’s life to others. AIDS deaths typically occur in young and middle-aged adults, i.e. in an age group that fulfils many important social and economic functions. The spillover value of an averted AIDS death is likely to be substantial – derived *inter alia* from the “love, care, guidance and knowledge” parents give to their children (which is important in the formation of human capital) (Bell, Devarajan, & Gersbach, 2004) and the role individuals play in connecting other individuals in social networks (which is important in the formation of social capital). Thus, our base-case valuation of the benefits of the “conditional scholarship” program due to averted AIDS deaths is likely to be an underestimate of its full benefits.

No study of the VSLY in Africa has been published. For comparison, we derive VSLY from the value of a statistical life (VSL) measured in other developing countries, using a method described previously (Moore & Viscusi, 1988). For Thailand in 2003 (Gibson, Barns, Cameron, Lim, Scrimgeour, & Tressler, 2007) and Cambodia in 2004 (Cameron et al., 2006) we derive, respectively, VSLY of five and 55 times per-capita GDP from surveys of stated preferences. For India in 1990 we derive VSLY of 220 and 306 times per-capita GDP from two VSL estimates published in a study of revealed preferences in the Indian labor market

(Shanmugam, 2000). These comparison values suggest that by using a VSLY of three times per-capita GDP in the base case we underestimate – perhaps severely – the social value of the “conditional scholarships”.

Composition of the minimum team

Our model assumes the same emigration rates for physicians, nurses, pharmacists and counselors. While physicians, nurses and pharmacists (FIP, 2006) have exportable skills in high demand in many developed countries, treatment counselors do not. Counselors, however, are more likely than the other three categories of health professionals to leave ART programs for other reasons, including work in other sectors (because their sector-specific training times have been shorter) or to pursue further training (because they have not yet reached a very high level of professional attainment). Thus, it seems reasonable to assume that counselors leave ART program in similar rates than the other types of health workers.

A second difference between counselors, on the one hand, and physicians, nurses and pharmacists, on the other hand, is that counselors can be replaced more quickly than the other types of health workers because their training times are shorter. However, new counselors will lack many of the health care and organizational skills that the experienced counselors they replace have acquired during work. In addition, the new counselors will lack the experienced counselors' knowledge of specific patients. High rates of counselor loss may

thus reduce the efficiency and clinical effectiveness of ART programs, justifying “conditional scholarships” for counselors.

We use estimates of numbers of health workers needed to treat a fixed number of patients from a period (up to the end of 2004 (Hirschhorn et al., 2006)) that predates the expanding practice of shifting specific tasks in ART care from highly qualified health workers to health workers with shorter training. According to recent WHO recommendations, a range of tasks that are traditionally performed by doctors could be performed by nurses without jeopardizing clinical effectiveness (e.g. assessing ART eligibility, initiating treatment-naïve patients on ART, prescribing first-line ART, and recognizing and managing self-limiting ART side effects) (WHO, 2008). If task shifting from physicians to nurses is implemented, it will increase the eNPV of “conditional scholarships”, because the same number of life years can be saved with lower upfront scholarship investment. Task shifting from physicians to so-called clinical officers, on the other hand, may reduce the need for interventions to lower emigration rates, such as “conditional scholarships”, because clinical officers are less likely to emigrate than either nurses or physicians (WHO, 2008). However, evidence from the US shows that clinical officers need to have easy access to physicians in order to be maximally effective in treating ART patients (Wilson, Landon, Hirschhorn, McInnes, Ding, Marsden et al., 2005). Thus, even if clinical officers were increasingly employed to deliver ART, “conditional scholarships” would remain a useful intervention.

Conditional scholarships” for HAHW and health systems

Currently, many ART programs in SSA are organized as vertical programs specializing in ART care. Our model does not make any assumptions about the health systems structures and processes in which ART is delivered other than that it will be delivered by a team composed of certain types of health workers. This team could work in a vertical ART program, but it could also work in ART services that are partially integrated (e.g. with TB treatment programs) or fully integrated with the overall health system.

While our model does not make any assumptions about the health system in which ART is delivered, we derive the value of the “conditional scholarships” from health workers delivering ART. Microsimulation shows that the eNPV of the “conditional scholarships” remains positive, even if health workers spend only some proportion of their work time delivering ART. For instance, mean eNPV is 0.45 million dollars for one minimum HAHW team assuming that scholarship recipients work only half-time delivering ART and that all other variables are at their base-case values. Our conclusion that “conditional scholarships” are a socially desirable investment thus continues to hold, even if health workers spend substantial proportions of their work time treating diseases that are not related to HIV.

Furthermore, our estimates of the numbers of different types of health workers needed to provide ART to one patient come from real-life ART programs. In these programs, HIV-positive patients commonly receive not only ART but also other health care. Although we estimate the “conditional scholarship’s” economic value with benefits stemming from ART delivery alone, its costs in terms of health workers’ salaries are likely to include some care for HIV-positive patients in addition to ART.

Our eNPV estimates, on the other hand, do not include any benefits of ART other than reductions in mortality of HIV-positive patients. People who need ART but do not receive it fall ill more frequently and more severely than patients on ART (Harling, Orrell, & Wood, 2007). The prevention of disease episodes in patients who receive ART because of the “conditional scholarship” program will be of positive economic value. Our eNPV estimates may thus underestimate the true social value of the conditional scholarships. From the perspective of the overall health system, the work of scholarship recipients will free up capacity of those health workers who would have treated disease episodes that are now prevented by ART.

In sum, scholarships for health care education in return for a commitment to deliver ART in SSA are currently a highly cost-beneficial intervention and are likely to remain cost-beneficial as ART programs mature and ART health workers increasingly fulfill functions within the general health care system.

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Figure 1: Sensitivity analysis of selected model variables

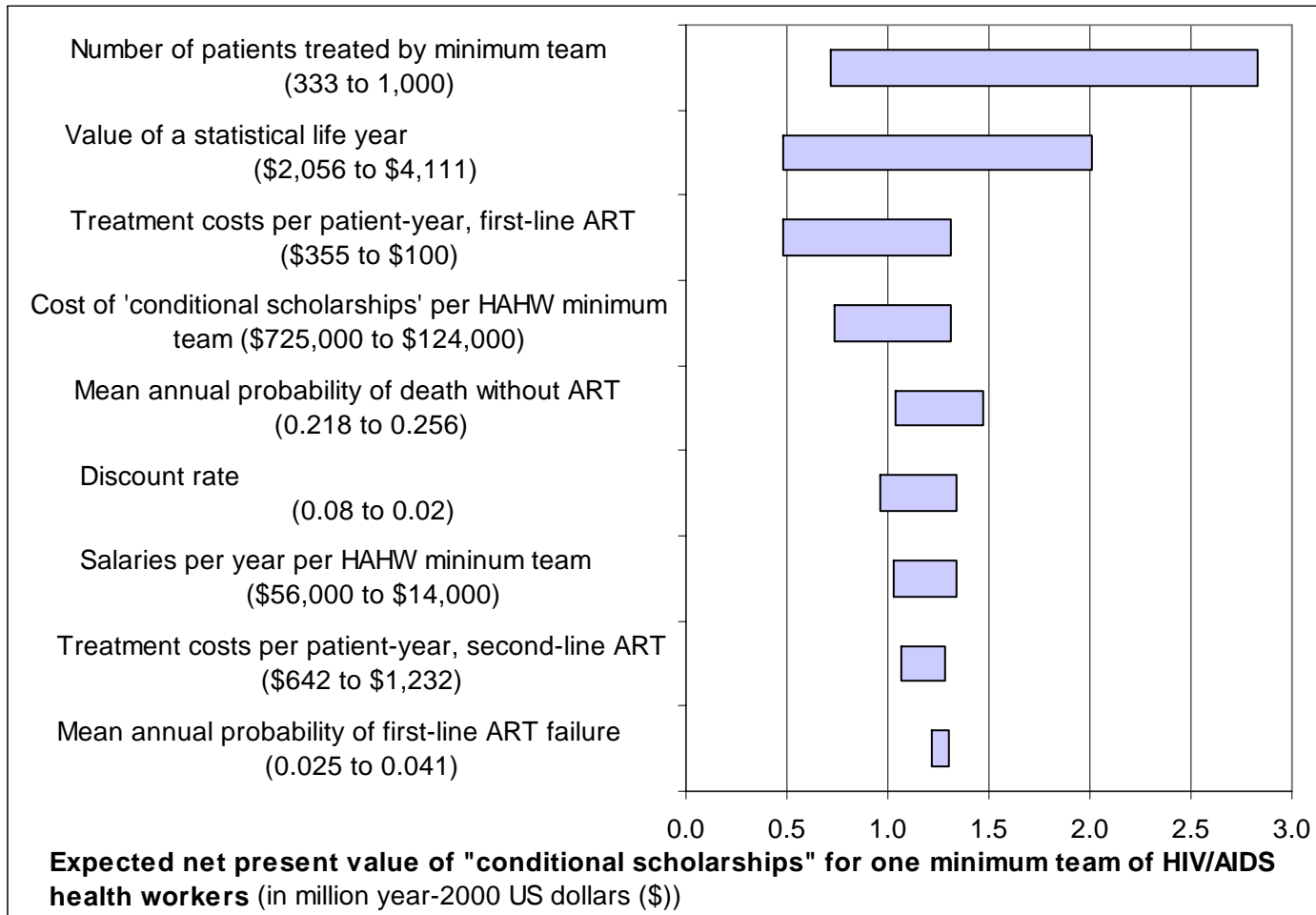


Table 1: Values of model variables

	Base-case	Minimum	Maximum	Reference
Value of a statistical life year (year-2000 US dollars)	3,084	2,056	4,111	(Commission on Macroeconomics and Health, 2001)
HAHW minimum team				
Ratio nurses : treatment counselors : doctors : pharmacists	3:10:1:1			(Hirschhorn et al., 2006)
Number of patients treated by minimum team	500	333	1,000	(Hirschhorn et al., 2006)
Education costs = value of “conditional scholarship” (year 2000 \$)				
Doctors	42,000	32,000	200,000	(Muula et al., 2006)
Nurses	24,000	19,000	95,000	(Kirigia et al., 2006; Muula et al., 2006)
Pharmacists	35,000	25,000	140,000	
Treatment counselors	3,000	1,000	10,000	
HAHW minimum team	179,000	124,000	725,000	
Salaries per year (year-2000 US dollars)				
Doctors	7,000	3,000	15,000	(Vujicic, Zurn, Diallo, Adams, & Dal Poz, 2004)
Nurses	2,000	1,000	7,000	(Vujicic et al., 2004)
Pharmacists	5,000	3,000	10,000	
Treatment counselors	700	500	1,000	(Foundation for hospices in sub-Saharan Africa, 2007)
HAHW minimum team	25,000	14,000	56,000	
Patient probabilities				
Mean annual probability of death without ART	0.237	0.218	0.256	(Badri et al., 2006)
Mean annual probability of death in first year of treatment, first-line ART	0.064	0.057	0.071	(Braitstein et al., 2006)
Mean annual probability of death in second or later year of treatment, first-line ART	0.027	0.022	0.032	(Braitstein et al., 2006)
Mean annual probability of death in second or later year of treatment, second-line ART	0.027	0.022	0.032	
Mean annual probability of loss to follow-up	0.100	0.024	0.156	(Marazzi, Guidotti, Liotta, & Palombi, 2005; Nacher, El Guedj, Vaz, Nasser,

Mean annual probability of first-line treatment failure	0.033	0.025	0.041	Randrianjohany, Alvarez et al., 2006) (Orrell, Harling, Lawn, Kaplan, McNally, Bekker et al., 2007)
HAWW minimum team probabilities				
Mean annual probability of emigration	See table 2			(Docquier & Bhargava, 2006)
Minimum team, age-specific probability of death	Age and sex-specific			(INDEPTH, 2004)
Treatment costs per patient-year (year-2000 US dollars)				
First-line ART	120	100	355	(South African Department of Health, 2004; WHO, 2007a, b)
Second-line ART	698	641	1,232	(South African Department of Health, 2004; WHO, 2007a, b)
CD counts	8	5	20	(Carter, 2004; ReaMetrix, 2007)
Cotrimoxazole prophylaxis	3	2	4	(WHO, 2007a)
Discount rate	0.03	0.02	0.08	

Table 2: Expected net present value of “conditional scholarships” for one minimum team of HIV/AIDS health workers

	Mean	95% CI	Mean	95% CI	Mean	95% CI
Increased education output only						
15% mean annual probability of emigration	799,067	(781,688 - 816,446)				
12% mean annual probability of emigration	954,097	(934,586 - 973,607)				
<i>Length of service commitment</i>	<i>3 years</i>		<i>5 years</i>		<i>7 years</i>	
Increased education output and decreased emigration						
5% mean annual probability of emigration during the service requirement; 15% otherwise	1,119,711	(1,102,096 - 1,137,325)	1,238,763	(1,220,025 - 1,257,501)	1,354,293	(1,334,562 - 1,374,024)
5% mean annual probability of emigration during the service requirement; 12% otherwise	1,284,889	(1,264,631 - 1,305,147)	1,349,004	(1,328,526 - 1,369,482)	1,417,743	(1,396,472 - 1,439,015)
3% mean annual probability of emigration during the service requirement; 15% otherwise	1,223,939	(1,206,584 - 1,241,295)	1,385,393	(1,366,789 - 1,403,997)	1,507,784	(1,488,342 - 1,527,226)
3% mean annual probability of emigration during the service requirement; 12% otherwise	1,343,552	(1,324,126 - 1,362,978)	1,476,995	(1,456,459 - 1,497,532)	1,607,055	(1,585,487 - 1,628,623)
Decreased emigration only						
5% mean annual probability of emigration during the service requirement; 15% otherwise	168,209	(143,923 - 192,496)	287,261	(262,350 - 312,172)	402,792	(377,232 - 428,351)
5% mean annual probability of emigration during the service requirement; 12% otherwise	148,670	(120,755 - 176,585)	212,785	(184,481 - 241,088)	281,524	(252,956 - 310,093)
3% mean annual probability of emigration during the service requirement; 15% otherwise	272,438	(248,674 - 296,202)	433,891	(408,920 - 458,863)	556,283	(530,696 - 581,869)
3% mean annual probability of emigration during the service requirement; 12% otherwise	207,333	(179,934 - 234,731)	340,776	(312,364 - 369,188)	470,836	(441,869 - 499,803)