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# Achieving the millennium development goals for health

## Cost effectiveness analysis of strategies to combat HIV/AIDS in developing countries

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### Abstract

**Objective** To assess the costs and health effects of a range of interventions for preventing the spread of HIV and for treating people with HIV/AIDS in the context of the millennium development goal for combating HIV/AIDS.

**Design** Cost effectiveness analysis based on an epidemiological model.

**Setting** Analyses undertaken for two regions classified using the WHO epidemiological grouping—Afr-E, countries in sub-Saharan Africa with very high adult and high child mortality, and Sear-D, countries in South East Asia with high adult and high child mortality.

**Data sources** Biological and behavioural parameters from clinical and observational studies and population based surveys. Intervention effects and resource inputs based on published reports, expert opinion, and the WHO-CHOICE database.

**Main outcome measures** Costs per disability adjusted life year (DALY) averted in 2000 international dollars (\$Int).

**Results** In both regions interventions focused on mass media, education and treatment of sexually transmitted infections for female sex workers, and treatment of sexually transmitted infections in the general population cost < \$Int150 per DALY averted. Voluntary counselling and testing costs < \$Int350 per DALY averted in both regions, while prevention of mother to child transmission costs < \$Int50 per DALY averted in Afr-E but around \$Int850 per DALY in Sear-D. School based education strategies and various antiretroviral treatment strategies cost between \$Int500 and \$Int5000 per DALY averted.

**Conclusions** Reducing HIV transmission could be done most efficiently through mass media campaigns, interventions for sex workers and treatment of sexually transmitted infections where resources are most scarce. However, prevention of mother to child transmission, voluntary counselling and testing, and school based education would yield further health gains at higher budget levels and would be regarded as cost effective or highly cost effective based on standard international benchmarks. Antiretroviral therapy is at least as cost effective in improving population health as some of these interventions.

### Introduction

The sixth millennium development goal, adopted by the United Nations in 2000, aims to halt by 2015 and begin to reverse the spread of HIV/AIDS. However, most countries face uncertain prospects of attaining this target. Shortage of resources is one important reason for slow progress; the projected funding gap for the year 2007 is estimated at around 50% of the need.<sup>1</sup>

In this study we focus on two related issues—whether resources currently available are achieving as much as they could and how best to use any new resources that become available.

The millennium development goals were defined when antiretroviral drugs were widely regarded as being prohibitively expensive. The goal for HIV/AIDS therefore focused on reducing transmission. Since then, the annual cost of first line antiretrovirals has fallen from more than US\$10 000 per patient to as low as \$140.<sup>2</sup> While halting the spread of HIV infection remains a critical—and unfulfilled—objective, there is also an urgent need to assess the extent to which treatment improves population health and is consistent with the intent of the goals. With the recent price reductions, re-evaluation of the cost effectiveness of treatment is essential.

This paper assesses the effectiveness and costs of a variety of interventions for preventing and treating HIV/AIDS, individually and in combinations that incorporate interactions between interventions in both costs and health impacts. The analyses focus on two particular regions with high HIV/AIDS burdens, classified using the World Health Organization epidemiological grouping—Afr-E, which includes those countries in sub-Saharan Africa with very high adult and high child mortality, and Sear-D, which includes those countries in South East Asia with high adult and high child mortality.

### Methods

Another article in this series provides details on the standardised methods used in all analyses in the series.<sup>3</sup> In this section we provide a brief overview of methods exclusive to this paper. (See [bmj.com](http://bmj.com) for complete details on modelling intervention effects, estimating costs, and sensitivity and uncertainty analyses.)

### Strategies for HIV/AIDS control

We considered the range of available interventions for preventing the spread of HIV infection in generalised epidemics and various strategies for treating people with HIV/AIDS. Our choice of interventions (see box) was limited by available data<sup>1</sup> and restricted to strategies that are most relevant to the epidemics in sub-Saharan Africa and South East Asia, where transmission occurs mostly through heterosexual contact.

**This article is part of a series examining the cost effectiveness of strategies to achieve the millennium development goals for health**

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*BMJ* 2005;331:1431–5



Further details of the methods used appear in an appendix on [bmj.com](http://bmj.com)



This is the abridged version of an article that was posted on [bmj.com](http://bmj.com) on 10 November 2005: <http://bmj.com/cgi/doi/10.1136/bmj.38643.368692.68>

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## Model

We adapted an existing model of the transmission and natural course of HIV/AIDS that was used previously to assess the potential impact of preventive interventions.<sup>5</sup> The model includes underlying regional demography, acquisition of HIV and other sexually transmitted infections, and progression from HIV infection to AIDS and death.

## Results

### Intervention effects

In both Afr-E and Sear-D regions the largest number of disability adjusted life years (DALYs) are averted through education and treatment of sexually transmitted infections for sex workers, while the smallest gains are from school based education. Tables 1 and 2 show the incremental cost effectiveness ratios for interventions, listed in the order that they would be added with increasing budgets if cost effectiveness were the only consideration. The figure shows this expansion path graphically, with the slope of the line joining any two points indicating the incremental cost effectiveness ratio for the more costly option (see related article by Evans et al<sup>3</sup> for further details). The size of intervention benefits reported here should not be compared with current epidemiological estimates since we compared interventions against a “no intervention” scenario, which subtracts current levels of condom use, treatment of sexually transmitted infections, and antiretroviral treatment.

The expansion paths for the two regions are similar. Interventions focused on mass media and peer

### Interventions for HIV/AIDS considered in this analysis

**Mass media**—Includes television and radio episodes and inserts in key newspapers, repeated every two years; development and administration costs included; effectiveness scaled by proportion of population reporting weekly exposure to radio, television, or newspapers

**Voluntary counselling and testing**—Performed in primary care clinics for anyone requesting the services; includes training of health workers; based on rapid test; number of tests over five year period assumed to be twice average annual prevalence

**Peer education for sex workers**—Training of selected sex workers by social workers to undertake peer education; provision of condoms

**Peer education and treatment of sexually transmitted infections for sex workers**—In addition to training of sex workers for peer education, referrals made for testing and possible treatment of sexually transmitted infections

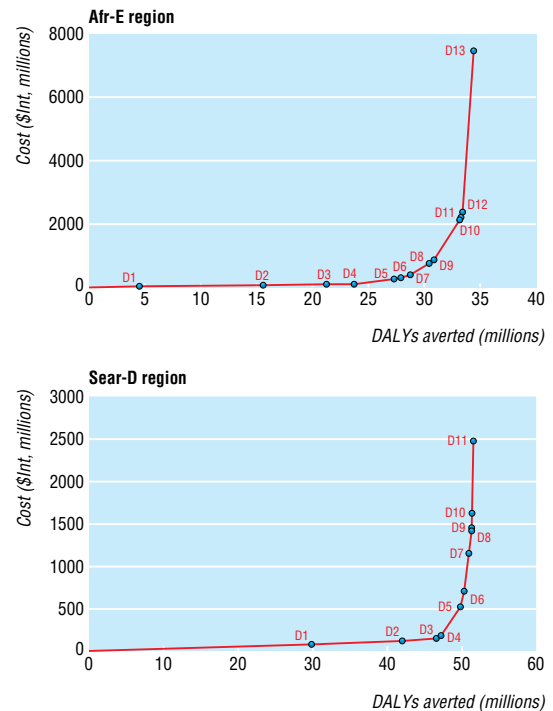
**School based education**—Targeted at youths aged 10-18 years; sessions provided during regular lessons to all students, to promote prevention of HIV and other sexually transmitted infections; includes training of selected teachers at each school

**Treatment of sexually transmitted infections (general population)**—Provided in primary care facilities, available to anyone who requests it; includes visits, drugs, counselling, advice on protection, and condom distribution if requested; effectiveness scaled by access and likelihood of using the services

**Prevention of mother to child transmission**—Information provided to women seeking antenatal care on benefits and risks of nevirapine for prophylaxis; pre-test counselling offered; single dose provided to women who accept, and single dose provided to child if delivered in a healthcare facility

**Highly active antiretroviral therapy (HAART)**—Standard HAART involves monthly visits to healthcare providers, while intensive monitoring involves weekly contact; either first line drugs only or first line drugs plus second line drugs when required

See appendix on bmj.com for further details



Expansion path for incremental addition of cost effective interventions for HIV/AIDS in regions Afr-E (top) and Sear-D (bottom). (See tables 1 and 2 for description of combinations D1-D13 and D1-D11)

education and treatment of sexually transmitted infections for sex workers would be adopted first if cost effectiveness were the only criterion for prioritising interventions. In Afr-E health gains, measured in DALYs, would be maximised by adding prevention of mother to child HIV transmission and treatment of sexually transmitted infections in the community next, followed by voluntary counselling and testing, antiretroviral therapy, and school based education. All of these interventions are highly cost effective based on standard benchmarks.<sup>3</sup> Using second line drugs in antiretroviral regimens would be the last addition to the package of interventions in Afr-E. In Sear-D decision makers considering only the maximisation of population health would add treatment of sexually transmitted infections in the community, voluntary counselling and testing, antiretroviral therapy (with first line drugs), and prevention of mother to child transmission—all highly cost effective<sup>3</sup>—before adding school based education or second line antiretrovirals.

Many sources of uncertainty cannot be captured in the usual statistical confidence intervals, including uncertainty about the quantity of inputs required to run a programme, the actual use of services by patients, and unit costs. We tested the sensitivity of the rankings to variation in the assumptions around key parameters, and the ranking of interventions remained stable (see appendix for details).

In Afr-E a reduction in programme costs relative to patient costs would make treatment of sexually transmitted infections at high coverage and school based education more cost effective. In Sear-D an increase in programme relative to patient costs would make preventing mother to child transmission more

**Table 1** Annual costs in international dollars (\$Int),\* DALYs averted, and incremental cost effectiveness of non-dominated† intervention combinations to control HIV/AIDS in Afr-E region

| Intervention package |                                                                                                    | Yearly costs<br>(\$Int, millions) | Yearly DALYs averted<br>(millions)‡ | Incremental cost effectiveness<br>ratio (\$Int/DALYs averted) |
|----------------------|----------------------------------------------------------------------------------------------------|-----------------------------------|-------------------------------------|---------------------------------------------------------------|
| No                   | Details                                                                                            |                                   |                                     |                                                               |
| D1                   | Mass media                                                                                         | 16                                | 4.5                                 | 3                                                             |
| D2                   | D1 + peer education and treatment of sexually transmitted infections for sex workers, 50% coverage | 57                                | 15.6                                | 4                                                             |
| D3                   | D1 + peer education and treatment of sexually transmitted infections for sex workers, 80% coverage | 79                                | 21.3                                | 4                                                             |
| D4                   | D1 + peer education and treatment of sexually transmitted infections for sex workers, 95% coverage | 89                                | 23.8                                | 4                                                             |
| D5                   | D4 + prevention of mother to child transmission, antenatal care coverage level                     | 249                               | 27.3                                | 46                                                            |
| D6                   | D5 + treatment of sexually transmitted infections, current coverage                                | 290                               | 27.9                                | 68                                                            |
| D7                   | D5 + treatment of sexually transmitted infections, antenatal care coverage                         | 357                               | 28.7                                | 80                                                            |
| D8                   | D7 + voluntary counselling and testing, 95% coverage                                               | 742                               | 30.5                                | 220                                                           |
| D9                   | D8 + treatment of sexually transmitted infections, expanded to 95% coverage                        | 859                               | 30.9                                | 290                                                           |
| D10                  | D9 + antiretroviral therapy, no intensive monitoring, first line drugs only                        | 2125                              | 33.2                                | 547                                                           |
| D11                  | D10 + school based education, 95% coverage                                                         | 2202                              | 33.3                                | 631                                                           |
| D12                  | D11 + antiretroviral therapy, intensive monitoring, first line drugs only                          | 2350                              | 33.4                                | 1144                                                          |
| D13                  | D11 + antiretroviral therapy, intensive monitoring, first and second line drugs                    | 7483                              | 34.4                                | 5175                                                          |

\*International dollars are a hypothetical unit of currency that has the same purchasing power that the US\$ has in the United States at a given point in time. Details of this approach are discussed elsewhere.<sup>3</sup>

†Excludes combinations that were more costly but less effective than others (dominated interventions) and those with higher incremental cost effectiveness ratios than more effective options (weakly dominated interventions).

‡Intervention benefits are not comparable with current epidemiological estimates because results in this analysis are computed in relation to a “no intervention” comparator, which subtracts current levels of condom use, treatment of sexually transmitted infections, and antiretroviral treatment.

attractive relative to other interventions. Uncertainty analyses also reveal stable outcomes across a range of plausible behavioural and biological assumptions in the 10 best fitting parameter sets (calibrated to match baseline projections) (see [bmj.com](http://bmj.com) for details).

## Discussion

This study re-examines HIV/AIDS intervention strategies in a way that allows critical assessment of the cost effectiveness of current strategies and plans for the future use of extra resources that may become available. We have evaluated interventions singly and in combination, taking into account synergies in both costs and effects when interventions are implemented concurrently.

Because of the substantial uncertainties in many of our assumptions, we suggest that our results be viewed by broad bands of incremental cost effectiveness ratios. For example, in sub-Saharan Africa mass media and providing education and treatment of sexually transmitted infections for sex workers are virtually indistinguishable in terms of incremental

cost effectiveness, but we can be more confident that school based education, at around \$Int600 per DALY averted—even subject to a relatively wide range of uncertainty—requires greater resources to produce a given health benefit than peer education of sex workers, at less than \$Int5 per DALY; or that use of second line antiretrovirals, at around \$Int5000 per DALY averted, is substantially more costly per healthy life-year gained than the initial introduction of first line antiretrovirals, at about \$Int500 per DALY.

## Implications of results

Our results indicate that syndromic management of sexually transmitted infections can substantially reduce the health burden of HIV/AIDS in the population. There has been extensive debate over the role of treating sexually transmitted infections in the prevention of HIV infection because of apparently discrepant findings in three large, community based trials.<sup>6–10</sup> Our results are consistent with recent syntheses of the findings from these trials,<sup>11 12</sup> which conclude that such treatment has substantial potential

**Table 2** Annual costs in international dollars (\$Int),\* DALYs averted, and incremental cost effectiveness of non-dominated† intervention combinations to control HIV/AIDS in Sear-D region

| Intervention package |                                                                                               | Yearly costs<br>(\$Int, millions) | Yearly DALYs averted<br>(millions)‡ | Incremental cost effectiveness<br>ratio (\$Int/DALYs averted) |
|----------------------|-----------------------------------------------------------------------------------------------|-----------------------------------|-------------------------------------|---------------------------------------------------------------|
| No                   | Details                                                                                       |                                   |                                     |                                                               |
| D1                   | Peer education and treatment of sexually transmitted infections for sex workers, 50% coverage | 83                                | 29.9                                | 3                                                             |
| D2                   | Peer education and treatment of sexually transmitted infections for sex workers, 80% coverage | 122                               | 42.1                                | 3                                                             |
| D3                   | Peer education and treatment of sexually transmitted infections for sex workers, 95% coverage | 141                               | 46.6                                | 4                                                             |
| D4                   | D3 + mass media, 100% coverage                                                                | 175                               | 47.3                                | 51                                                            |
| D5                   | D4 + treatment of sexually transmitted infections, 95% coverage                               | 511                               | 49.8                                | 133                                                           |
| D6                   | D5 + voluntary counselling and testing, 95% coverage                                          | 693                               | 50.4                                | 317                                                           |
| D7                   | D6 + antiretroviral therapy, no intensive monitoring, first line drugs only                   | 1149                              | 51.0                                | 760                                                           |
| D8                   | D7 + prevention of mother to child transmission, antenatal care coverage level                | 1416                              | 51.3                                | 850                                                           |
| D9                   | D8 + antiretroviral therapy, intensive monitoring, first line drugs only                      | 1443                              | 51.3                                | 1295                                                          |
| D10                  | D9 + school based education, 95% coverage                                                     | 1620                              | 51.4                                | 2192                                                          |
| D11                  | D10 + antiretroviral therapy, intensive monitoring, first and second line drugs               | 2481                              | 51.6                                | 4406                                                          |

\*International dollars are a hypothetical unit of currency that has the same purchasing power that the US\$ has in the United States at a given point in time. Details of this approach are discussed elsewhere.<sup>3</sup>

†Excludes combinations that were more costly but less effective than others (dominated interventions) and those with higher incremental cost effectiveness ratios than more effective options (weakly dominated interventions).

‡Intervention benefits are not comparable with current epidemiological estimates because results in this analysis are computed in relation to a “no intervention” comparator, which subtracts current levels of condom use, treatment of sexually transmitted infections, and antiretroviral treatment.

to reduce HIV transmission, particularly in HIV epidemics at less advanced stages, as in both of the regions examined here (compared with the epidemic in Uganda). Our conclusion that treating sexually transmitted infections would be among the most cost effective interventions against HIV transmission should, however, be revisited as new information emerges.

Another important finding is that antiretroviral therapy would be included in a package of interventions for HIV/AIDS in both regions on the basis of cost effectiveness. A strict literal interpretation of the stated targets in the millennium development goals would limit the focus to interventions that reduce transmission, and evidence on the impact of treatment on transmission remains limited. However, treatment offers relatively good value for money in both regions in terms of broad measures of population health outcomes. Cost effectiveness ratios for first line HAART are lower than those for school based education, and some variant of HAART falls well below the threshold for very cost effective interventions in both regions. Although we found the addition of second line antiretrovirals to be relatively costly per added year of healthy life, their prices could well fall, as did the costs of first line treatment, which would lower these cost effectiveness ratios accordingly.

In addition, the direct impacts of antiretroviral therapy reported here might understate the overall social benefits of treatment. For example, the availability of treatment may encourage people to present voluntarily for counselling and testing, which is critical to overcoming denial, stigma, and discrimination—among the main barriers to effective prevention. It would also allow key workers such as those in the medical and education sectors to report more regularly for work, thereby relieving staff shortages in those sectors in many countries. These issues reinforce the finding that antiretrovirals should be offered in combination with preventive strategies.

#### Limitations of study

Several limitations in this study deserve mention. Some interventions that were not included in this analysis may be effective strategies. In addition, the interventions that we did include have been formulated in a small number of ways among the many possibilities. For example, we considered a basic variant of preventing mother to child transmission that falls short of the most recently published official recommendations.<sup>13</sup> Although a regional analysis is intended to provide broad guidance to decision makers, many factors can cause variability in both costs and effects of interventions across settings. Although they are unlikely to affect our overall conclusions, continuing efforts are required to expand the scope of strategies that are analysed and consider additional alternatives for feasible implementation.

Many important uncertainties remain about the trajectory of HIV/AIDS epidemics and the potential effectiveness of interventions when expanded to full scale. Developing a better understanding of sexual behaviours in different settings will be critical, as will strengthening the empirical link between behavioural and epidemiological models. In considering the likely impact of interventions, we extrapolated most assump-

#### What is already known on this topic

Previous studies of intervention priorities for HIV/AIDS in resource poor settings have either focused on comprehensive intervention packages or assembled cost effectiveness outcomes from independent studies of individual interventions

Recent reductions in costs of antiretroviral drugs make re-evaluation of the cost effectiveness of treatment essential

#### What this study adds

A comprehensive and standardised analysis of available interventions singly and in different combinations shows that "best buys" in HIV prevention include mass media campaigns, interventions focused on female sex workers, and treatment of other sexually transmitted infections

Cost effectiveness criteria would support the inclusion of antiretroviral therapy in a package of high value interventions, and treatment is expected to produce other benefits not captured in a cost effectiveness framework

tions from a limited number of relatively small scale studies, so precise and reliable estimates of the effectiveness of large scale prevention programmes are still needed.

#### Conclusions

We emphasise that decisions are never made only on cost effectiveness criteria. Many other factors influence priority setting. For HIV/AIDS in particular, arguments have been made in support of general or specific intervention strategies based on ethical criteria and human rights, so policy makers should interpret our results in the context of these other important considerations.

A previous analysis indicated that the millennium development goal for HIV/AIDS could be achieved by application of a comprehensive response to prevention and treatment.<sup>14</sup> Our analysis suggests that the financial constraints to implementing such a comprehensive approach to combating HIV/AIDS should not be regarded as the principal obstacle. A critical policy question that remains, however, is how to ensure that the massive undertaking required to respond effectively to the HIV pandemic can be sustained. Our findings that a combination of prevention and treatment can be highly cost effective brings into sharper focus the importance of overcoming other constraints such as managerial needs, political commitment, infrastructure, and human resource requirements.

We acknowledge valuable comments from David Evans, Tessa Tan-Torres, Stephen Lim, Jim Yong Kim, and Yves Souteyrand. We thank Peter Ghys, Karen Stannecki, and Neff Walker for providing baseline estimates and forecasts of HIV prevalence, John Stover for much useful input and guidance in development of the model, Kevin O'Reilly and George Schmid for helpful discussions on interventions, and Mark Sculpher and Virginia Wiseman for their constructive reviews of this and other papers in the cluster.

Contributors: See [bmj.com](http://bmj.com)

Funding: WHO provided financial support for the study in the form of salary support for staff members (JAL and CH) and funding for RB and DRH. WHO staff members received no external funding. Members of the WHO-CHOICE team helped frame the questions for the analysis and provided guidance on standardised methods. DRH and JAS were supported by a grant (P01 AG17625) from the National Institute on Aging, which had no role in the study design, execution, or reporting.

Competing interests: None declared.

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(Accepted 12 October 2005)

doi 10.1136/bmj.38643.368692.681

## Parental concerns about their child's emotions and behaviour and referral to specialist services: general population survey

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Childhood psychiatric disorders are common and are associated with heavy use of health services.<sup>1</sup> Up to a third of children and adolescents attending primary care and paediatric outpatient departments have clinically significant psychopathology.<sup>2,3</sup> Only a minority of these children reach specialist mental health services, partly because the presenting complaint is rarely psychological, so their disorders may not be recognised.<sup>2,4</sup> Child mental health services may reject inappropriate referrals leading to frustration among referrers and families.

Although medical professionals often depend on parental concerns to identify affected children, we do not know how predictive they are. We used empirical data from the 1999 British child and adolescent mental health survey to examine how predictive parental perceptions of psychological difficulties were of psychiatric disorder and to provide simple strategies to aid clinicians in identifying children requiring referral.<sup>1</sup>

### Participants, methods, and results

We used the child benefit register to select a nationally representative sample of 10 438 children aged 5-15 years from Great Britain. The Development and Well Being Assessment combined information from parents, teachers, and young people aged 11 and older to diagnose psychiatric disorders according to the

*Diagnostic and Statistical Manual of Mental Disorders*, fourth edition.<sup>5</sup> Parents completed the Strengths and Difficulties Questionnaire, which generates total difficulties and impact scores.<sup>6</sup> The latter indicates the level of distress and related impairment in family life, peer relationships, academic functioning, and leisure activities.

Parents were also asked whether their child had "hyperactivity," "behavioural problems," and "emotional problems" and whether teachers had complained about the child's concentration, activity level, or impulsiveness. We cross tabulated parents responses to these questions with the presence of psychiatric disorder to elicit ways in which clinicians might assess which children require referral.

The negative predictive power and specificity of parental opinions were high, suggesting that clinicians can mostly be reassured by a lack of parental concern (table). About half of the children that parents were worried about had a psychiatric disorder; almost three quarters of parents reported problems in more than one area. Many of the children identified as having difficulties by parents will have significant problems even if they fall below the threshold for a psychiatric diagnosis. The Strengths and Difficulties Questionnaire total symptoms and impact scores were much higher in the "parent concerned but no diagnosis" group (n = 396) than the "no parental concern" group

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BMJ 2005;331:1435-6