OPTIMIZING THE ALLOCATION OF RESOURCES FOR HIV PREVENTION: THE ALLOCATION BY COST-EFFECTIVENESS (ABC) MODEL

GUIDELINES

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1. Introduction

In the context of a growing HIV/AIDS epidemic and limited resources for prevention, the Allocation By Cost-Effectiveness Model (ABC Model) is designed to help policymakers decide how to distribute funds between different HIV prevention interventions to achieve the maximum impact on the epidemic. Specifically, policymakers can use the ABC Model to determine the resource allocation that will prevent the maximum number of new HIV infections at any given budget level.

These guidelines present the Allocation By Cost-Effectiveness Model and show how it can be applied to a particular country or region. They are meant to be used in conjunction with the ABC Spreadsheet and give a detailed description of how to fill the ABC spreadsheet, how to read the output results, and what issues to consider when interpreting them. For a specific application of the ABC Model, refer to: Optimizing the Allocation of Resources among Prevention Interventions in Honduras. The World Bank 2002[a].

2. Summary Description of the Model

The ABC Model calculates the impact of allocating resources among different HIV prevention interventions and, for each budget level, chooses the allocation that yields the greatest number of prevented HIV infections. The underlying spreadsheet draws on the techniques elaborated in No Time to Lose.[4] The ABC Model has the following characteristics:

Aims to prevent the largest number of new HIV infections[b]. The model defines the optimal resource allocation as that for which the HIV prevention budget is divided such that the largest number of new HIV infections are prevented. This methodology follows that of a classic maximization problem which can be expressed as follows: How does one maximize the number of new infections prevented given a production function for HIV prevention and a resource constraint? The resource constraint is the available budget for HIV prevention and the production function transforms "dollars spent" into "infections averted". This production function is the aggregate of intervention specific functions that show, for each prevention intervention, the number of infections that can be prevented in a particular target group at different budget levels. These functions are built using estimates relating to the epidemiology of HIV and the cost and effectiveness of specific prevention programs for each target subgroup.[c]

Focuses on prevention programs only. Since the model seeks to maximize the number of 'infections prevented', it does not consider tradeoffs between funding care and treatment as opposed to prevention. It supposes that the policymaker has already earmarked funds for prevention.

Analyzes alternative allocations differentiated by strategy and target group. The model seeks the optimal allocation not only by intervention, but also by target population. Population subgroups are identified by characteristics such as risk behavior, sexual orientation, sex, language, location and HIV/AIDS prevalence. These population groups are then mapped onto prevention interventions to present the results in terms of allocation of resources among prevention interventions rather than among population groups. This is to facilitate policymakers' use of the model, as they are more likely to manipulate funding by interventions than by population groups.

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[a] Both this paper and the associated spreadsheet with data from Honduras: ABC Model - Honduras, can be found at: www.worldbank.org/lachealth/

[b] In "No Time to Lose", the optimal allocation of available public resources for HIV prevention is defined as one that prevents the maximum number of new HIV infections.

[c] For a mathematical formulation of the model, see The World Bank 2002 (Appendix I) www.worldbank/lachealth

Enables other allocation criteria such as equity or political concerns to be valued explicitly in comparison to the optimal allocation. The model gives the policymaker the option to reserve funding for a particular group or program, and compare this with the optimal allocation by measuring the resulting impact on the number of infections averted.

The ABC Model is based on an XL spreadsheet with 8 worksheets: an introductory worksheet (Introduction); two worksheets for data entry ('Data Entry' and 'Data Entry (Step 3)'); two worksheets presenting the results in the form of tables ('Results-Optimal Allocation' and 'Testing Alternative Allocations'); and three worksheets presenting the results in the form of graphs ('Effectiveness of Interventions', 'Optimal Allocation – Resources', and 'Optimal Allocation – Prevention'). In the following section we discuss some methodological aspects related to data gathering, before presenting the seven steps involved in data entry. In Section 5, we explain how to read the results and in Section 6, we discuss important caveats inherent in the model that should be kept in mind when interpreting its output.

3. Methodological considerations

The optimization exercise requires the gathering of a substantial amount of data, including: (i) defining the population groups targeted for intervention and their respective sizes; (ii) estimating the proportion of these subgroups that can be reached; (iii) estimating the total number of new infections expected in each; (iv) defining the set of HIV prevention interventions to be considered; (v) estimating the unit cost of each intervention; and (vi) estimating the expected effectiveness of each intervention. Policymakers, however, may have little information on the size of some of the key target populations, on the number of new infections expected to occur in each of these groups, and on the effectiveness of different prevention interventions.

In the absence of available data, a second best alternative may be the estimation of the data by consensus by a group of experts. One possible strategy to generate consensus estimates is as follows: first, all the relevant data that can be obtained from surveillance systems, national statistics, and from local and international studies should be collected to produce an initial estimate of all the variables that feed into the model; second, these initial estimates should be reviewed by a large group of experts during a workshop that culminates in the generation of consensus estimates for all input values[d].

This approach has several advantages: (i) it brings all available expertise together to ensure that the estimates are as close as possible to reality; (ii) it generates ownership of the model since all stakeholders participate not only in the validation of the input data, but also in the definition of the key groups to be targeted and the interventions to be considered; and (iii) it ensures a transparent and participative process of the interpretation of the model's results.

4. Data Entry to Run the Optimization Model

The data entry process involves seven steps. Throughout the spreadsheet, blue cells are for data entry, which must be in the correct corresponding format: text (for the definition of population subgroups, interventions, etc) or numeric (for the population size, cost of interventions, etc.). White cells should not be modified. If a cell turns red, it means that data entry in the cell or in adjoining blue cells is incorrect.

For each of the seven data entry steps, we specify which blue cells must be filled in the worksheets 'Data Entry' and 'Data Entry (Step 3)', and the format in which the data should be

[d] This two-step approach was used successfully in the application of the ABC Model to Honduras.

entered (text, number, or percentage). All steps except Step 3 refer to the worksheet 'Data Entry'. Step 3 refers to the worksheet 'Data Entry (Step 3)'. In addition, for each step, we discuss specific data issues and describe how the model handles them.

Step 1: Definition of target population groups.

The first step involves the definition of the population target groups, their respective sizes, and the proportion of each that can realistically be reached by a given intervention. Step 1 can be divided as follows:

a) Define the target population groups: cells C6-C20 (text format). Replace "group 1", "group 2", etc. in cells C6-C20 by the names of the chosen groups. The definition of population groups can use criteria such as, risk behavior, age, HIV prevalence, susceptibility to interventions, etc. The spreadsheet allows a maximum of 15 population groups to be defined. The total population of the country or region under consideration should be included and it is therefore recommended to have a group called "rest of the population" which includes everyone who is not in a target group.

b) Estimate the size of each population group: cells D6-D21 (numeric format). The size of each of the population groups defined in Step 1.a) must be estimated and entered in column D, next to the name of the corresponding group. The total population of the country or region under consideration should be entered in cell D21, and if applicable, the "rest of the population" group should have a population equal to D21 minus the population of all other groups.

   Ideally, the population groups should be exclusive, but some overlap may be inevitable given the targeting strategies employed. The ABC Model, however, does not correct for double counting of those persons who have more than one specific characteristic that puts them at risk. To illustrate this, let us consider the example of a pregnant adolescent commercial sex worker. Assuming the country under analysis had three different interventions targeting adolescents, pregnant women and commercial sex workers, respectively, she would be in all three groups and exposed to the three different interventions. Population groups would thus not be made exclusive because each of these three characteristics is important in its own right when determining how to target an individual through a given intervention. The consequence of this non-exclusiveness is that the sum of new infections expected in the next year in the high-risk groups does not correspond to the number of new infections that would be given by an epidemiological model. However, this does not have a significant impact on the allocation of resources as the size of the population groups does not affect the cost-effectiveness of the interventions.

c) Estimate the proportion of each group that can be reached by a given intervention: cells E6-E20 (percentage). It is assumed that not all individuals of a given population group can be reached by an intervention, because of identification problems (i.e. not all commercial sex workers, for example, can be found or identified) or geographical difficulties (access to remote communities), among others. Therefore, an estimate of the proportion of each group that can realistically be reached by any given intervention should be entered in cells E6-E20. Column F (cells F6-F20) will then automatically show the maximum number of people in each group that is estimated to be reachable by the interventions.

Step 2. Estimation of HIV incidence rates for each group.

Estimate the HIV incidence rate in each population group in the upcoming year, in the absence of any additional prevention activities: cells I6-I20 (percentage). Several methods have been developed worldwide to estimate incidence rates in high-risk populations. These include cohort studies, cross-sectional samples, back calculation from reported AIDS incidence to historical HIV infection rates, study of immunological markers for HIV infection, and snapshot analysis[1,2,5,6]. However, if these methods are not available, it might be necessary to rely on the existing information from previous studies in the country/region under consideration, and on the judgment of experts working in the area. Alternatively, the HIV incidence rate can be estimated from available prevalence data using the AIDSProj Spreadsheet Model[10]. This model generates epidemiological projections based on available data and derives incidence figures from prevalence data.

Using the incidence rates entered in cells I6-I20, column G (cells G6-G20) calculates the number of new HIV infections (also called primary infections) expected in the following year in each group in the absence of additional prevention interventions. This is simply the incidence (column I) times the size of the population of the corresponding group (column D). Alternatively, if the number of new infections expected for the following year in a given group is known, it can directly be entered in cells G6-G20 and the corresponding incidence calculated in column I.

Step 3. Secondary infections

Calculate the number of secondary infections that arise from each primary infections in each group: 'Data Entry (Step 3)' worksheet. Since an HIV infected person can transmit the infection to others, when estimating the benefits of preventing an HIV infection, it is necessary to take into account not only the benefits for the immediately affected individual but also for those whom this individual might otherwise have infected, thus incorporating potentially significant 'multiplier effects'[e]. Studies have shown that some low-risk groups might be better protected from interventions in linked high-risk groups than from direct interventions[7]. To estimate the number of secondary infections, the following parameters must be estimated and entered in the cells corresponding to each population group in the 'Data Entry (Step 3)' worksheet:

a) HIV prevalence in each population group: cells B18-P18 (percentage).

b) HIV prevalence in the partners of each population group: cells B19-P19 (percentage).

c) Transmission probability per unprotected contact (in the absence of a sexually transmitted disease (STD) other than HIV/AIDS): cells B20-P20 (percentage).

d) Prevalence of ulcerous STDs in HIV+ve individuals from the group: cells B21-P21 (percentage).

e) Prevalence of non-ulcerous STDs in HIV+ve individuals from the group: cells B22-P22 (percentage).

f) Infectivity modification factor for the coexistence of ulcerous STDs: cells B23-P23 (number).

g) Infectivity modification factor for the coexistence of non-ulcerous STDs: cells B24-P24 (number).

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[e] An example of the multiplier effect is that by ensuring that commercial sex workers consistently use condoms, infections are prevented among CSWs but also among their clients and the partners of their clients[12].

h) Percentage of protected contacts (i.e. % of contacts where condom was used): cells B29-P29 (percentage).

i) Protection (condom) effectiveness: cells B31-P31 (percentage).

j) Average number of contacts per sexual partner per year: cells B32-P32 (number).

k) Number of sexual partners per year: cells B33-P33 (number).

l) Expected years of life after HIV infection for a person in the group: cells B34-P34 (number)

References for some of these estimates, especially c), f) g) and i), can be found in the ABC Model – Honduras.

With input data a) through k), the number of secondary infections that arise from each primary infection in each group and the total number of secondary infections generated by all primary infections of each group are calculated using a Bernoulli model[f, 8, 9]. This latter number is then automatically reported in the worksheet 'Data Entry', in cells H6-H20.

If the input data a) through k) are not available and difficult to estimate, one option is to subjectively estimate the number of secondary infections generated by an individual in each of the population groups. These numbers can then be entered directly in the 'Data Entry' worksheet, cells H6-H20. In this case, the 'Data Entry (Step 3)' worksheet should be left in blank. Alternatively, the model can be run without secondary infections, thus leaving both the 'Data Entry (Step 3)' worksheet and cells H6-H20 in the 'Data Entry' worksheet in blank. By omitting secondary infections, however, the optimal allocation may give less weight to interventions aimed at groups with a high risk of transmitting the infection on to others. The relative importance of these groups in preventing the further spread of the epidemic and the impact of targeting them would thus no longer be emphasized.

Step 4. Definition of the prevention interventions to be included in the analysis.

Define the prevention interventions that should be included in the analysis: Cells D25-R25 (text format). The ABC Model allows for a total of 15 interventions to be included in the analysis. These interventions can be defined, for example, on the basis of existing program design at national or regional level and international best practice. They can include collective interventions that reach across several population groups simultaneously (such as mass media campaigns) and interventions aimed at specific groups of individuals (for example, condom distribution in a particular target group).

The components of each intervention must also be broadly defined as they are key for the estimation of the cost (Step 6) and the effectiveness of each intervention (Step 7) – see below.

By basing allocation decisions on interventions rather than on population subgroups, the model is of greater use to policymakers, but generates technical difficulties. To ensure a correct optimization process, corrections are included in the model that make sure that once a group has been saturated (i.e. once all its members have been reached by the intervention) additional funds allocated to the same intervention are redirected to the members of another group that has not been saturated yet.

[f] For the mathematical formulation, refer to The World Bank 2002 (Appendix I) www.worldbank/lachealth.

Step 5. Estimation of the composition of the population reached by each intervention.

Out of the total population reached by each intervention, estimate what percentage corresponds to each population group: cells D26-R40 (percentage). For example, let us assume that: Intervention 1 is "Condom distribution in high risk groups"; Group 1 is commercial sex workers; Group 2: men who have sex with men; and Group 5: prisoners. If we now assume that out of 100 people targeted by condom distribution in high risk groups, 50 are commercial sex workers, 30 men who have sex with men and 20 prisoners, the Data Entry worksheet should be filled as follows: 50% in cell D26; 30% in cell D27; and 20% in cell D30. The same procedure should then be repeated, column by column, for each intervention. If the sum of a given column (between cells 26 and 40) does not equal 100%, the corresponding cell 41 will automatically turn red, alerting to the mistake.

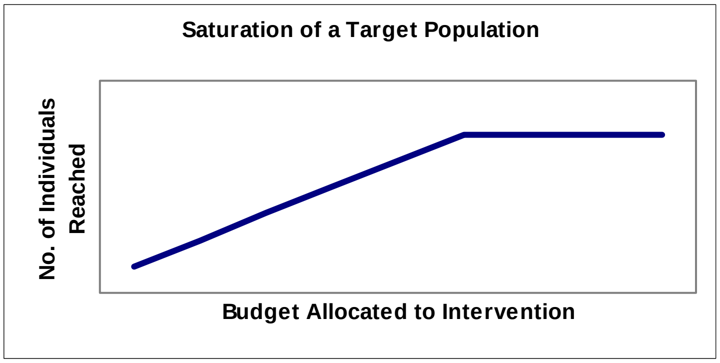
Step 6: Estimation of the number of people reached by each intervention at each level of funding.

In this step, the number of people reached by each intervention at each budget level is estimated: cells D46-R65 (number). There are several ways to do this, the easiest being as follows:

a) Define a realistic budget increment: cell C46. The total prevention budget over which the analysis is performed is then shown in cell A48 and will depend on the amount entered in cell C46. For example, if $250,000 is entered in cell C46, the optimal allocation analysis is done for prevention budgets ranging from $0 up to $10 million, in increments of $250,000. If $1 million is entered in cell C46, $40 million appears in cell A47, which means that the analysis will now be done for prevention budgets ranging from $0 to $40 million, in increments of $1 million. This cell can be changed at any moment during the analysis to expand the budget horizon.

b) Estimate the average cost of reaching one person for each intervention. To do this, the components of each intervention must be defined. The average unit cost for each intervention is entered in cells D66-R66. The worksheet then calculates the rest of the table automatically by dividing the total prevention budget by the unit cost for each intervention. For example, if the budget increment defined in a) was $250,000 (cell C46), and if it costs $10 to reach each person with Intervention 1, then $10 should be entered in cell D66, and the table will automatically show that at $250,000, Intervention 1 reaches 25,000 people (cell D46); at $500,000, 50,000 people (cell D47), and so forth.

This simplification assumes that for a given intervention, the cost of reaching individuals is linear between zero and a given saturation point, beyond which the cost is infinite (i.e. no more people can be reached). This saturation point was implicitly determined in Step 1 c) when the proportion of each population that could be reached by a given intervention was estimated. This cost structure can be represented graphically as follows:



When using average cost-effectiveness rather than marginal cost effectiveness, it is assumed that it is as easy to reach the first 100 persons in any population group as the next 100 persons in that group. It would be more realistic and accurate to use marginal costs for each intervention based on real cost curves. However, considering the difficulty of obtaining such data, this simplification can be used by the model.

Alternatively, if the data is available, more complex cost curves (taking into account fixed and marginal costs) can be constructed for each intervention, the number of people reached at each budget level calculated, and these numbers entered into the spreadsheet in the cells corresponding to each intervention and budget level (cells D46-R65 – which is why these cells are in blue, although if the former option is chosen, they need not be modified).

Step 7: Estimation of the effectiveness of each HIV prevention intervention.

Estimate the percentage of new infections that are prevented in each population group reached by a given intervention: cells D70-R84 (percentage). For example, assume that Intervention 3 (say, peer education) is expected to prevent 50% of all new infections among commercial sex workers (Group 1) and 30% of all new infections among prisoners (Group 5). In this case, the table should be filled as follows: 50% in cell F70 and 30% in cell F74.

Effectiveness data can be estimated by drawing on available figures from the international literature, and by relying on the judgment of experts. The percentage reduction in risk behavior, can be used as a proxy for the percentage of HIV infections prevented. This means that a decrease in the percentage of unprotected contacts, for example, can be used as a measure of the effectiveness of a given intervention.

Note that the relative effectiveness of different interventions is more important than the absolute numbers. In other words, even given the difficulties inherent in estimating effectiveness data, it is important to focus on the relative ranking of the different interventions as determined by the defined effectiveness measures. Similarly within a given interventions, the relative effectiveness in different population groups should be considered.

Given that the effectiveness data estimated in this step are for each intervention working in isolation, the ABC Model applies a correction factor to account for the fact that the effectiveness of an intervention in isolation is not the same as its effectiveness in parallel with other interventions. To illustrate this, suppose a country has an incidence of 1,000 cases of HIV infection per year. Applying a hypothetical Intervention A which prevents 30% of these infections, one would be left with an annual incidence of 700. A second intervention (Intervention B) with an effectiveness of 25% would now prevent 25% of 700 infections, and not 25% of the original 1,000 infections. Therefore, the collective effectiveness of multiple interventions is less than the sum of the effectiveness of each intervention, and this is taken into account automatically by the spreadsheet.

5. Reading the Results

Once all the data has been entered in steps 1 through 7, the results of the optimal allocation exercise can be seen in 5 different worksheets, as described below.

Results-Optimal Allocation Worksheet

This worksheet includes 6 tables. To make it easier to give specific examples, we will assume that the minimum budget increment (cell C46 in the Data Entry worksheet) was defined as $250,000.

The first table: Number of New Infections Prevented (cells C2-R23) shows how many HIV Infections could be prevented if a given amount of funding was allocated to a given intervention. This table assumes that each intervention is working in isolation. For example, cell G9 shows how many infections can be prevented if $1.5 million is allocated to Intervention 4.

The Second Table: Optimal Resource Allocation at each Budget Level (cells C27-R68) shows the optimal allocation at each budget level. In other words, for a given budget level, it shows how much money should be given to each intervention to prevent the maximum number of HIV infections. Line 36, for example, shows how to allocate $2 million among the different interventions: cell D36 is the amount that should be allocated to Intervention 1, cell E36, the amount that should be allocated to Intervention 2, cell F36 to Intervention 3, and so forth.

Table 3, Infections Prevented for each Budget Increment (cells B75-D116) shows: (i) the number of infections that can be prevented by each additional amount of funding (cells C76-C116), and (ii) the cumulated number of infections prevented by each total budget level, if allocated optimally. For example, cell C84 shows how many additional infections are prevented if the total prevention budget is increased from $1.75 million to $2 million, and cell D84 shows the total number of HIV infections that can be prevented with $2 million allocated optimally.

The three next tables show what happens for the maximum budget – which corresponds to $10 million if the minimum budget increment was defined as $250,000. The total number of infections that can be prevented with $10 million is disaggregated by population groups and by interventions. Infections Prevented by Population Group shows how many HIV infections can be prevented within each population group with a prevention budget of $10 million allocated according to the optimal allocation presented in cells D68-R68. Infections Prevented by Intervention shows how many HIV infections can be prevented by each intervention with $10 million allocated optimally. Finally, the table Cost-Effectiveness of Each Intervention disaggregates the total cost per infection prevented (cells E118 and S112), and shows for each intervention how much it costs to prevent an infection.

Testing Alternative Allocations Worksheet

This worksheet includes 3 tables. The first table presents the results of the Optimal Allocation for a Given Prevention Budget. The total budget available for HIV prevention should be entered in cell R73. The table then shows how this budget should be divided among the different interventions (cells C4-Q4) to prevent the maximum number of infections. It also shows the corresponding number of HIV infections that can be prevented by each intervention (cells C5-Q5).

Because policymakers cannot allocate prevention budgets purely on the basis of cost-effectiveness, tables 2 and 3 of this worksheet enable them to simulate the effect of alternative resource allocation strategies on the number of infections prevented. The second table: Results of Alternative Allocations allows policymakers to determine how much they wish to allocate to each intervention by filling in cells C84-Q84. (Note that the amount allocated to each intervention must be a multiple of the minimum budget increment defined previously – cell F87 in this worksheet). The resulting number of infections prevented can then be seen in cells C86-Q86 (by intervention) and cell R86 (total).

The third table Reserved Funding for Specific Interventions Followed by Optimal Allocation provides a simulation for an intermediate strategy, where a minimum amount is reserved for certain interventions and the remainder of the budget is submitted to the optimization exercise. Here, the policymaker should enter the minimum amount that should be allocated to certain priority interventions in cells C93-Q93. Then, the total available HIV prevention budget should be entered in cell R94. (Note that the amount in cell R94 should be superior to the amount appearing in cell R93, which is the sum of all reserved spending). The spreadsheet will then show in cells C95-Q95 the final amount allocated to each intervention, which includes the minimum (reserved) amount and the amount assigned through the optimal allocation of the remaining budget. In addition, the number of infections prevented is shown in cells C97-Q97 (by intervention) and cell R97 (total).

These three tables enable the policymaker to analyze resource allocation strategies that differ from the optimal scenario and explicitly measure the effects of social or political constraints in terms of foregone prevention opportunities (i.e. less HIV infections prevented).

Effectiveness of Interventions Graph

This Graph uses the data entry information to generate effectiveness curves for each intervention. These curves show, for each intervention, how many infections can be averted at each level of funding. The model uses these curves to generate the optimum allocation of resources for different HIV prevention budgets.

Optimal Allocation – Resources Graph

This worksheet shows in a graphical format how funds should be allocated between different prevention interventions at each budget level. (This is the same information as that found in the table: Optimal Resource Allocation at each Budget Level in the 'Results-Optimal Allocation' worksheet). To read the graph, one can choose a specific budget level on the x axis, and then trace a vertical line upwards from the axis to see which interventions it crosses and at what funding levels.

Optimal Allocation – Prevention Graph

This worksheet shows in graphical format how many infections are prevented by each additional amount of funding, and the total number of infections prevented for each HIV prevention budget distributed according to the optimal allocation. (This is the same information as that found in the table: Infections Prevented for each Budget Increment in the 'Results-Optimal Allocation' worksheet).

6. Interpreting the Results

As suggested earlier, the model works well in the context of a workshop where all the stakeholders in HIV prevention are invited to test out and discuss the implications of alternative resource allocation proposals. The following points, however, are worth noting when analyzing and interpreting the results of the optimization exercise:

- The results apply marginally, i.e., for incremental budget allocations, not for the overall budget allocations. For example, if the analysis suggests that no money should be allocated to a particular intervention, it does not mean that all the budget that is currently allocated to the intervention in question should be retrenched, but that no *additional* resources should be allocated to the intervention.

- The model weighs all infections prevented equally, irrespective of the mode of transmission or the characteristics of the person who has been saved from infection. In other words, the infection of a baby through maternal-child transmission and a new infection acquired through a commercial sex act are weighed equally[g]. The results of the model – whose singular purpose is to locate the resource allocation strategy that maximizes the *number* of new infections averted – must thus be discussed widely to allow for corrections in the weights assigned to an infection in each population group[h].
- Enabling factors may be key for a given intervention to achieve expected results. Political will and leadership, for instance, are needed for the adoption of certain HIV prevention strategies (especially those involving marginalized groups). In addition, certain interventions with low cost-effectiveness may provide an important synergistic effect to other interventions prioritized by the model, but the model does not take into account the positive effects of one intervention on the effectiveness of another.
- The recommendations are valid to the extent that the interventions consist of the specific strategies underlying their cost and effectiveness estimates. Should the package of strategies that constitute a particular intervention be altered for technical or socio-political reasons, then the cost of the intervention and its effectiveness should also be updated and the model re-run with the new parameters.

One possible result from the exercise is the identification of a small number of interventions with very high cost-effectiveness. This may lead to the definition of a minimum package of key interventions that must be carried out because of their potential impact on the epidemic. A minimum amount of funding may then be set aside for these cost-effective measures, while the remaining HIV prevention budget is used to compensate for socio-political and/or ethical considerations and to fund strategies with medium to long term impact.

In conclusion, the ABC Model may help policymakers simulate the effect of alternative resource allocations, generate consensus around the HIV prevention interventions that have the greatest impact on the epidemic, and monitor and evaluate the outcome of the chosen strategy.

[g] To take the age at infection into account, the model offers the option of using 'Years of Life Lost (YLL) averted' instead of 'HIV infections averted' as the objective function. By using YLL instead of infections averted, more weight is ascribed to the prevention of an HIV infection among newborns and adolescents than to the prevention of an HIV infection in the rest of the population. To run the model in terms of YLL averted, in the Data Entry worksheet, cell N3 must be changed from INF to AVP and cells N6-N20 must be filled with the average age at death for each group. All results will then be in terms of YLL averted.

[h] See Hammer (1993)[3] for a discussion of the gap between people's preferences and the valuations of life implicit in cost-effectiveness ratios.

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