



Critical Review of Costing Models to Estimate Resource Needs to Address Global HIV and AIDS

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Table of Contents

Abstract.....	4
Introduction.....	5
Overview: Ideal and Existing Approaches	5
Resource Needs Model (RNM)	7
World Bank ABC (Cost-Effectiveness) Model	17
GOALS Model.....	19
Estimation Based on the Elasticity of HIV/AIDS Activities	21
Complementary Models.....	22
Models for other Millennium Development Goals.....	24
Conclusion	27
References.....	27

Abstract¹

To assist UNAIDS in refining global resource estimates for addressing HIV/AIDS we review existing approaches for estimating the resource requirements to address HIV/AIDS in low and middle income countries globally. The only existing comprehensive approach identified by this research group is the UNAIDS resource needs model (RNM). This model has great practical advantages of clarity and an ability to work effectively with existing data. Nevertheless, the model has a number of limitations. It excludes interaction effects among interventions on cost, coverage, or results. It ignores possible economies of scale for varying the magnitude of a single intervention or implementing related components simultaneously. Finally, it does not incorporate the promising synergy between care and prevention.

This analysis found that other models for resource allocation, particularly the ABC cost-effectiveness model and the GOALS model, are not comprehensive approaches but could contribute substantially to development of models of global resource needs. This document next reviews promising approaches from other Millennium Development Goals (MDGs), particularly the techniques used to cost Target 10 around water supply and sanitation. This information can be used to develop novel approaches to address resource projection.

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Introduction

In the last decade, the global fight against HIV/AIDS has attracted substantial attention and garnered tremendous commitments of support from governments of affected countries, international donors, foundations, non-profit groups, and the general public. Full and sustained financing of HIV/AIDS activities has been widely recognized as the key determinant for the successful response to the global HIV/AIDS crisis [1], yet the amount of resources that effort requires is less clear [2]. In order to plan, implement, monitor, and/or extend HIV/AIDS activities, resource needs must be estimated. Resource estimation will guide UNAIDS and other agencies in trying to mobilize the necessary resources, and to help suggest the most effective allocation of those resources.

Overview: Ideal and Existing Approaches

As a framework for examining both existing and recommended approaches, we think it is useful to describe an ideal model for resource estimation. The ideal model would specify, for each country, the intensity of each preventive and curative service in each country of the world by year, with the associated cost. Strong evidence would indicate that the interventions will allow each country to achieve the AIDS Millennium Development Goal, and that the proposed plan is the least costly among all possible plans. The global resource needs for low and middle income countries would be calculated as the sum of the needs in each of these countries.

An ideal model thus incorporates several demanding features: it would be dynamic, in which the severity and interventions of the epidemic in one year affect its severity in the next

year. It would incorporate optimization, so that the user would have confidence that the proposed plan is the least expensive. It would incorporate evidence based epidemiological modeling linking the interventions to outcomes.

Our literature review did not identify any real world model that fully satisfies this ideal. Nevertheless, we found several models that address important components of this idealized model. In the remainder of this part of the report, we describe and critique the components identified. In the subsequent part, we suggest alternative and novel approaches. Some of these are based on extensions of the approaches reviewed.

Since 1996, experts from international organizations (UNAIDS, WHO, and World Bank), and research and consulting institutions have developed several methods for estimating HIV/AIDS resource needs. The approach already in use by UNAIDS, the UNAIDS Resource Needs Model (RNM), is the most comprehensive of the existing approaches. However, several other existing models were found that answer closely related questions and could be adapted to estimate global resource needs. These are: the World Bank ABC Model (Cost-effectiveness model for HIV prevention), GOALS Model, and the method based on elasticity. In addition, we include the Global Fund Resource Estimation Model and the Optimization Model, as useful tools for planning the needs in one major international donor and for allocating resource among different populations respectively.

In addition to the field of HIV/AIDS, we searched for literature on models and approaches for helping to cost Millennium Development Goals, Production Frontiers Analysis Model and costing model, in other sectors.

Resource Needs Model (RNM)

The resource needs model (RNM) was first applied in 1996, and was originally used for estimating the resource needs for global prevention and treatment activities, using several clearly-defined interventions [3]. With an increased understanding of the comprehensive activities in HIV/AIDS control and the availability of relevant data in recent years, the model has evolved and become more refined, and new components have been added. UNAIDS refined this model and adapted it estimating global resource needs, as described in a 2005 UNAIDS working paper [4]. In addition to prevention and treatment, three additional components were incorporated: support for orphans and vulnerable children (OVC), human resources, and program cost (see Table 1). This analysis of RNM is based on 2005 UNAIDS paper.

Table 1. RNM Measurement of Population in Need, Coverage and Unit Cost

Component	Population in need	Coverage	Unit cost
Prevention	Target groups differ among interventions. Some groups are segments of population while others represent the entire population.	The target coverage rate for each intervention was set at realistic and necessary levels, with the overarching goal of turning the epidemic around by 2010. Differences in prevalence rates were taken into account.	Unit costs for most prevention components were derived from country specialists or published descriptions of pilot projects. Regional averages were used for those countries that had no data. Unit costs were assumed to remain constant through 2008
Treatment	Two definitions were applied as part of the estimation process. One was the number of people who, in the absence of antiretroviral therapy, would likely die within two years. Another was the number of patients who experienced AIDS-related symptoms within the past year.	The target coverage goal was to reach 80% of the people in need by 2010. The coverage rates after 2006 were increased by a constant rate per year.	Unit costs were derived from a Global Fund dataset on pricing, and were expressed as the lifetime cost for general treatment.
Support for orphans & vulnerable children (OVC)	In sub-Saharan African, all orphans were included in the estimates. In other regions, however, only the proportion of OVCs resulting from AIDS was counted.	The target coverage goal was 100% by 2010	Costs were based on estimates from UNICEF, and were assumed to be similar to those that were required to assist OVCs in sub-Saharan Africa.
Human resources	Human resource requirements were based on the number of physicians and nurses that were needed per patient on antiretroviral therapy.		Costs included those for educating needed additional health personnel, costs, as well as the costs of recruiting and retaining medical staff.
Program cost	Inputs were estimated by expert teams from each region.		Costs were estimated based on interviews with program experts, and consisted of recurrent cost and capital cost.

The RNM seeks to identify those interventions and activities that are associated with the five components (i.e., prevention, treatment, OVC, human resources, and program cost), with the ultimate goal retrieving and/or estimating information falling under three broad categories: the population in need, coverage, and unit cost. Finally, the resource requirements for each intervention are combined by intervention and by category in order to estimate total resource needs.

The RNM is the most common method currently in use for estimating global HIV/AIDS resource requirements. By 2005, the RNM was used to construct numerous country-specific estimates (at least 23 countries in Latin America and 29 in Eastern and Central Europe) and global estimates. Conceptually, this model is intuitive and straightforward. The resource requirements for comprehensive programs are calculated by multiplying the population in need, coverage, and unit cost. The data requirements for RNM are clearly defined, with a comprehensive catalogue of data items, and a division of activities within each of the five major categories. The model requires detailed information on each service (either from published reports or experts), and the operational manual specifies the required steps for carrying out a resource estimation exercise [5]. While a systematic review on this model has already been published [6], we suggest several potential refinements. Our suggestions focus on the structure of the model, and not its data requirements.

Identify Interventions

In terms of identifying interventions, the first step of RNM, UNAIDS reported in 2005 selected 19 interventions in prevention, 7 for treatment, and 5 for OVC [4]. In order to address the HIV/AIDS epidemic adequately, the chosen interventions ought to be proven developments

in HIV/AIDS prevention, treatment, and care. As our knowledge of HIV/AIDS improves, these interventions will undoubtedly change. In this sense, RNM is an open-ended model, and more services and interventions could be included (or omitted) as needed.

In the RNM, the scope of the interventions was often narrow due to data limitations or lack of availability. The most noticeable case was human resource needs[6]. RNM estimates focused only on doctors and nurses and did not consider other categories of HIV/AIDS personnel. As human resource requirements for HIV/AIDS-related activities extend beyond physicians and nurses, the RNM might somewhat underestimate overall human resource needs[4, 6]. Given the severe shortage of human resources in low- and mid- income countries, human resources managers have adopted alternate strategies for retaining HIV/AIDS workers including: shifting task, and providing incentives to retain current human resources. These techniques used to mitigate personnel shortages are also likely underreported [7]. In addition, human resource cost estimates might be impacted workforce turnover (i.e., the incremental cost of training new physicians or nurses from scratch).

Define the Population in Need

Resource estimates for activities in prevention, treatment, and care for OVC requires information on the target population and coverage-levels in order to properly assess resource requirements. For the human resources and program cost estimates of the RNM, no specific information target population and coverage is needed. Instead, they require the information on quantity of the resource for the activities. The limitations concerning population in need are only relevant to the prevention, treatment, and care for OVC.

Conceptually, the target population for preventive or curative services is the collection of people receiving a service due to HIV/AIDS that they would not have received if the disease did not exist. Operationalizing this concept proved challenging in the RNM. For some services, the RNM interpreted the concept in incremental resources, such as the incremental costs per additional doctor or nurse required for scaling-up program activities. The same incremental estimation was applied to program costs, as well. Similarly, outside of sub-Saharan Africa, however, OVC status was restricted to those children who were orphaned as a result of the AIDS-related death of a family member or care-giver. On the other hand, within sub-Saharan Africa, orphans from all causes, HIV/AIDS-related or not, were included in the estimates. For example, the Rwanda National AIDS Commission (CNLS) reported that while the majority of the 1,260,000 OVCs in the country 2002 were the result of AIDS, genocide and war were additional contributing factors (CNLS, 2002).

Setting the Coverage Rate

Low coverage of key interventions is a severe obstacle for reducing the spread of HIV/AIDS. At least in the short-run, this effort will likely require a rapid scaling-up of prevention and treatment activities [8]. The NRM endeavored to set target coverage rates at levels that could reduce the spread of HIV/AIDS by 2010, even at the current increased rate of spread. However, the assumption that there will be a constant rate of spread seems problematic, particularly when setting target goals for HIV/AIDS activities. One needs only to look at previous vaccination efforts in order to find insight on this particular issue. For instance, studies have shown that the extent of vaccination coverage can be scaled-up more rapidly in counties with a lower level of coverage and progressed slower (and sometimes leveled-off) at the higher-

levels of coverage [9, 10]. Such patterns suggest that additional resources should be invested with the overarching goal of maintaining a constant and high-level of coverage over time.

Estimating Unit Cost

RNM assumed all unit costs are constant, regardless of the volume of production. Thus, it calculates total cost of each service by multiplying the constant unit cost associated with the intervention times the product of the target population and the coverage rate. However, this simplifying assumption differs from economic theory, which usually assumes that unit cost may vary with scale. For example, at low-levels of coverage, an increase in coverage is more likely going to result in a lower unit cost. One study estimating cost of prevention interventions targeting commercial sex workers in India showed a classic U-shape cost curve (i.e., where the cost decreased with an initial increase in volume, but then began to increase with additional volume) [11]. Moreover, interventions (preventative or curative) tend not to be carried out in isolation. As HIV/AIDS activities become more comprehensive and integrated, there may be some savings resulting from cost-sharing. However, when coverage reaches a moderately higher level, diseconomies of scale apply as the unit cost increases. So for interventions with a high target coverage rate, which are most likely reserved for only key interventions, estimations using a fixed unit cost may result an overestimation of resource needs in short run, and an underestimation in the long term.

Beside the effect of scale, it has been reported that the unit cost also varies by education, age, and health status. For example, unit cost might vary based on the experience and training of providers [12]. Other factors might be standardized by setting clinical protocols, but clearly some variance cannot be addressed. In particular, as AIDS patients get older and symptoms

become more salient and more severe with time, it is unrealistic to assume that a fixed unit cost would apply. Also, successful treatment can result in people living longer. This, in turn, extends the length and cost of treatment. Apart from requiring more treatment episodes, the proportion of patients on second line therapies might also be expected to increase. In addition, patients can be expected to experience more complications should the disease progress, or if they become resistant to certain treatments.

Considering Interactions

The interaction among interventions in HIV/AIDS field has been well documented [13-16]. These interactions generally occur in four ways:

a) Interaction among interventions within a single program component, such as prevention, treatment, or OVC support. Although the RNM costs activities separately, most preventive or curative interventions are not implemented in isolation, but as part of a comprehensive program. For example, clinics that provide services for PMTCT may also distribute condoms or offer voluntary counseling and testing. We would expect that interactions within a program component might generate economies of scale as some activities are performed jointly.

b) Interaction between different program components, typified by the interplay of the treatment program and the prevention program. The need for treatment depends largely on the prevalence of HIV/AIDS a few years earlier. Thus, successful prevention interventions will greatly reduce the cost for the treatment in the long run. Prevention and treatment could also decrease the number of OVCs through reductions in the spread of infection and/or patients living longer. Treatment programs also raise awareness, and improve coordination and cooperation

between treatment and prevention professionals. This generally has a strong effect on the interventions, by getting the message to target populations more efficiently [16]. We would expect, on balance, in the short run an increased awareness and higher costs resulting from consideration of interactions. In the long run, these interactions can affect costs (in either direction).

c) Interaction between HIV/AIDS activities and other diseases or other Millennium Development Goals. Considerable evidence has demonstrated the combined impact that TB and other infectious diseases can have upon HIV/AIDS. Consequently, efforts committed to curb TB and other disease among people with HIV would likely reduce the severity of the symptoms, as well as treatment costs. The presence of other conditions, such as sexually transmitted diseases, can increase the risk of HIV transmission [17, 18]. HIV infection can worsen other conditions. For example, patients infected with the TB bacillus and malaria parasite can become clinically ill due to the suppression of their immune system. RNM estimates resource needs intervention by intervention. Given the complicated synergic effect of HIV/AIDS interventions and their components, it might be more appropriate to incorporate more horizontal relations between interventions in the estimation process.

d) Interaction between HIV/AIDS activities and other Millennium Development Goals. Addressing HIV/AIDS may contribute to other United Nations (UN) Millennium Development Goals (MDGs), such as gender equity. Gender-specific and/or gender-empowering HIV/AIDS activities might address both goals simultaneously [19]. It is likely that refinements will need to be made to the RNM in order to account for resources that are devoted to these kinds of multi-goal interventions, and joint costs would need to be allocated.

Resource Allocation and Absorptive Capacity

While each intervention and activity in RNM is clearly outlined and detailed, the model contains no optimization procedure. Therefore, it is unclear whether the allocation of resources among activities within a program component, or between program components, is economically efficient. Cost-effectiveness analysis might provide additional insight that might prove helpful in gauging the appropriate distribution of resources across the five major HIV/AIDS components. Similarly, estimates of absorptive capacity might be useful for implementing programs and identifying inefficiencies, and as a factor for estimating resource needs. Slides from the research team's presentation to the Technical Working Group on Global Resource Needs provide further approaches (see Appendix 2).

Sensitivity Analysis

The RNM could also be enhanced by sensitivity analyses to address the uncertainties around each of its parameters. In its current implementation, the model presents a single number for each parameter – target population for a service, coverage, and unit cost per person covered. Users of the model need to derive their best estimates from available data. For many of the parameters, existing information may be anecdotal or available only from a convenience sample of sites that are not necessarily representative. A single number cannot adequately reflect the range of uncertainties on these multiple variables. Sensitivity analysis, one of the core components in cost-effectiveness analysis and other analytic techniques, provides a framework for addressing uncertainties. We would examine uncertainties in two categories: static and dynamic.

Static uncertainties are incomplete information about each parameter at the time that the estimates are made. For example, if the only data on unit costs come from a convenience sample of facilities, possibly few in number, we need to judge the range of values that would have been obtained from a large, random sample. Similarly, if the existing methods of costing were incomplete (e.g., study counted local costs but not international technical assistance), the sensitivity analyses needs to extrapolate to the range of costs that would be generated under fuller costing procedures.

The dynamic uncertainties relate to the change in variable over time. For example, the price reduction of HIV/AIDS drug might continue to reduce the unit cost for treating patients, at least for those patients treated with first-line anti-retroviral drugs. In the past few years, we have witnessed a dramatic price reduction of the some anti-HIV drugs. More generic drugs are available in the developing world. Similarly, the change of unit cost for other key interventions, the change of the population in need of services, and change of the capacity to implement the programs against HIV/AIDS may all change (hopefully fall) with increasing scale and increasing experience. Furthermore, prevention and treatment are expected to create positive synergies. As more counseling is done, more patients are identified who need treatment. From the other direction, the availability of treatment may encourage more persons to overcome their inhibitions against being tested. There could also be a potential harmful effect, sometimes called the San Francisco effect after some interpretations of the experience in that city, in which improved survival of treatment could lead to more risk behavior (what economists term moral hazard). Dynamic sensitivity analyses would look for evidence of each of these phenomena and incorporate them if and when they are relevant.

World Bank ABC (Cost-Effectiveness) Model

Given the limited resources for prevention of HIV/AIDS in most developing countries, the World Bank proposed the ABC cost-effectiveness model to improve the allocation of resource to control HIV/AIDS. Mathematically, the model aims to maximize the number of prevented new HIV infections subject to a budget constraint [20, 21]. Each potential intervention is assumed to be a linear relationship in which costs and prevention infections increase in proportion to coverage up to a maximum saturation level of coverage. Beyond that level, no further benefits are possible from that intervention. This optimization problem is solved by allocating the resource successively to the most cost-effective interventions. Essentially, the model uses the principles of cost-effectiveness analysis to find the most cost-effective interventions in terms of cost per HIV infection prevented. Initial applications of the model were in Honduras, Panama, and Guatemala[22]. The model's operation guidelines specify detailed processes for using expert panels to obtain best estimates of the needed information to calibrate the model to a country. The output of the model is a recommended allocation of resources to each intervention, and an estimate of resulting number of infections prevented.

Implementation of the model requires a moderately large amount of country specific data. Requirements include specifying the population groups targeted for possible intervention and their respective sizes, the maximum proportions of these subgroups that can be reached, total number of new infections expected in each group, the unit cost of interventions under study, and the expected effectiveness of each intervention[20]. These data may be obtained from empirical studies where possible. However, many of the items may need to be estimated by the model's users and then validated by an expert panel.

This model has many strengths. First, it has an important conceptual underpinning—allocating resources in the most efficient way based on the single outcome, infections prevented. Second, the model is flexible and can simultaneously incorporate other allocation criteria such as equity or political concerns. As its authors suggested, some resources can be reserved for specific prevention interventions, such as ensuring a safe blood supply, even if they do not rank highest on cost-effectiveness criteria. In this way, the model can overcome an apparent limitation of cost-effectiveness analysis as an over impersonal and technological approach to resource allocation.

Another advantage of this model is feasibility of obtaining plausible estimates of the necessary data. For example, cost analyses are based on the average unit cost of each service instead of the incremental unit cost. The specification of a saturation level of coverage is a usable approximation to the complex idea of diminishing returns to scale as the coverage of an intervention increases.

A limitation of the model is that the results may be very dependent on the subjective estimates from the required expert panels. Given the dearth of information about the effectiveness of prevention activities, the panel's estimates are very prominent for this parameter. The application in Honduras found that this model is very sensitive to the estimate of the saturation ceiling regarding the share of each target population that can be reached. Sensitivity analyses showed that with different assumptions on the reachable coverage of commercial sex workers, men who have sex with men, and the Graifunas (a minority population in Honduras), the avertable new infections could double given the same budget[20]. Similarly, the relative sizes of different target groups and their levels of saturation likely vary substantially among countries. Thus, the interventions that are highly cost-effective in one country may not rank that

favorably in another country which is regarded as effective in one country may not be in another country.

An additional limitation of the ABC model is that in certain cases (generally for countries with severe budget constraints for HIV/AIDS), it may recommend allocating minimal or no funds to certain HIV/AIDS activities based on the less favorable cost-effectiveness ratios. While technically sound, such recommendations may be ethically or politically questionable. Similar to the RNM, the model does not take into account the potential synergic effect of HIV/AIDS activities.

The ABC model assumes that the preventive interventions are independent. Under the given budget, the model would allocate funding first to the most cost-effective intervention up to its saturation point; it would then distribute remaining funding to second most cost-effective intervention up to its saturation point, and on and on. In practice, interventions are likely intertwined. For example, investment in advocacy may not prevent many interventions by itself. On the other hand, it may increase demand for other preventives services, such as voluntary counseling and testing or prevention of mother to child transmission.

GOALS Model

The GOALS model, developed by Futures Group International, has been applied in Kenya, South Africa, Lesotho, and Cambodia[23]. This model is not explicitly designed to estimate the resource needs for HIV/AIDS, but for strategic planning. Similar to the ABC model, the GOALS model focuses on resource allocation among interventions. The scope of interventions is broader, however, including prevention, treatment, and care and support.

The user of the GOALS model begins with an initial proposed budget distribution among interventions or activities of prevention, care and treatment, support, and program operation. Based on the corresponding unit costs, the model derives the coverage of each intervention. It then estimates the resulting direct or indirect effect on risk behaviors, such as condom use, seeking treatment for sexually transmitted infections (STIs), number of sexual partners, and age at first sex. The model incorporates an HIV transmission model to estimate how behavior changes reduce the number of new infections, incidence, and prevalence of HIV[24]. The model's documentation explains that decision makers could try different ways to allocate the budget among the HIV/AIDS activities, and determine one which is more suitable plan for their counties by observing the final output and/or considering other criteria.

The breadth of the GOALS model is another strength. Unlike the ABC model, which addresses only prevention interventions, the GOALS model incorporates treatment and care, support, and program operation. These components are now recognized as important determinants of the efficiency of the behavior changes[24].

Nevertheless, the model has a number of limitations. First, the model contains no link between rates of treatment and prevalence of HIV. This shortcoming creates a substantial challenge when trying to estimate the resource needs to achieve combined goals (e.g., universal access to treatment and lower prevalence among young adults).

Information on unit costs of interventions is a key item to derive the coverage of interventions. The model's authors recommend using local estimates of unit cost for interventions whenever possible. If no local data are available, the model will then incorporate an international value for the cost as a default value. It is likely that the results of the GOALS

model are very sensitive to the assumed unit cost, in the same way that the results of ABC model depended heavily on the estimated saturation levels of interventions. Since unit costs vary considerably among countries [24], the applicability of the international unit cost remains uncertain.

Estimation Based on the Elasticity of HIV/AIDS Activities

Elasticity indicates the rate at which one economic variable changes as another variable changes. The concept is commonly used to express the relation of quantities demanded or supplied on price, or the relation of outputs to inputs. If these elasticities were known, a policy maker could specify the level of inputs required to achieve specified levels of output. As with other techniques, studies to furnish the relevant data are few and their generalizability is uncertain. A contingent-valuation study of participants from Kenya and Tanzania found that, at least in developing countries, the public tends to overestimate its willingness to pay for HIV/AIDS counseling and testing services[25]. This research group has not located any literature on the elasticity of supply of HIV/AIDS services (changes in quantities offered) as a function of price. Even if such estimates were found, their generalizability to different market structures would be limited.

Estimation of future resource needs based on the elasticities tends to assume that decision making units (DMUs) are equally efficient in their design, production capabilities, and distribution of resources. Palmer and Torgerson postulate three measures of efficiency: technical, allocative, and productive[26]. According to Farrell, DMUs that are technically efficient operate on the apogee of the production possibility frontier (or output frontier) given current resources (or inputs)[27]. DMUs that have allocative efficiency, on the other hand, maximize resources

while maximizing the dispersion of outputs (or outcomes) within internal systems[26]. Productive efficiency refers to the maximization of a particular output (or outcome) at a given level of inputs (resources), or the minimization of inputs (resources) in order to achieve a desired output (or outcome)[26]. Potentially each efficiency measure could be applied to estimating resources for one country's HIV/AIDS activities. However, it would be an overwhelming challenge to execute such a task on a global scale, considering the diverse range of development (particularly with regards to their health systems), funding sources (i e., foreign and domestic, public and private), funding levels, and levels of absorptive capacity among countries worldwide.

Complementary Models

Two other models that have been used to resource estimation or resource allocation in HIV/AIDS field are model that used by the Global Fund to estimate the resource needs for funding HIV/AIDS, TB, and malarial activities, and the Optimal Model to allocate resource among populations.

The Global Fund's Resource Estimation Model

The model used by the Global Fund was originally developed to project the Global Fund's resource needs for funding HIV/AIDS, TB, and malaria activities. Thus, it was not specifically developed to estimate global HIV/AIDS resource requirements [28]. The model used information from the Global Fund's four rounds of funding between 2002 and 2004 to project the Global Fund's resource needs for 2005 through 2007. The Global Fund initiated each of the four rounds by inviting HIV/AIDS proposals from low and middle income countries, funding the best proposals, and disbursing funds according to agreed benchmarks.

Although it is difficult to apply this model to estimate the global resource needs for HIV/AIDS, it may be worthwhile to examine how the Global Fund, as one of the major international donors in HIV/AIDS, estimates its fundraising requirement to meet the appeal from the countries.

Methodologically, the Global Fund's resource estimation itself is somewhat imprecise. This method assumes that those resources that were allocated by the Global Fund fulfill countries' overall resource requirements when, in fact, it is more likely that they represented funding gaps that existed within countries. Some countries do not receive any funding from Global Fund not because they do not need HIV/AIDS resource, but rather because they lack technical capacity and/or political commitment to succeed in the proposal process.

Optimization Model

The other approach, the optimization model, has also been applied to questions related to HIV/AIDS resource allocation. The optimization model combines epidemiological modeling and optimization techniques in order to determine an optimal allocation of resources. When applied to HIV/AIDS resource estimation, the model has been used to determine how to distribute funds among different population groups, with the goal of minimizing negative HIV/AIDS outcomes within the United States. Furthermore, it models the non-linear scaling of costs and health benefits that may be applicable to resource allocation problems involving infectious diseases[29, 30]. The model does not, however, address the costs of any of the interventions. Also, it focuses only on prevention and does not consider treatment, support, or program activities.

Models for other Millennium Development Goals

Production Frontiers Analysis Model

Production frontiers analysis has been used in a variety of settings in order to assess health sector efficiency, as well as to evaluate country-level performance in achieving certain HIV/AIDS targets. Recently, the method was used to estimate global expenditure gaps in fulfilling other MDGs [31]. For health goals, the frontier was established by selecting top performers on the country's age specific mortality rate, an important health indicator, as a function of the country's level of per health expenditure. Countries were then compared based on their health spending relative to the best performer. The difference between the performance of any given country and the best performing country constitutes a performance gap.

Despite the promise of the frontiers approach in studying health outcomes, the feasibility of applying this technique to HIV/AIDS in the short run is uncertain. The first challenge is an outcome measure. Reduction in prevalence could, in theory, assess the accomplishments of the prevention components. However, as treatment extends the life of persons living with HIV/AIDS, it would increase prevalence. Thus, a prevalence indicator would be a perverse measure for a comprehensive program that includes both prevention and treatment. Conceptually, some indicator of DALYs gained from prevention, treatment, and OVC support could be defined, but the data and modeling needs for a robust estimate would be substantial. Because of the dynamics of the AIDS epidemic, modeling would also need to consider the natural evolution of the epidemic in the absence of any program or the absence of an expanded program.

A second challenge is the limited availability of data on HIV/AIDS spending. Since resource gaps are estimated primarily for countries with lower HIV/AIDS performance and/or

lower HIV/AIDS spending per capita compared to frontier countries, the production frontiers model may overlook inefficient spending (i.e., countries who spend up-to or beyond the efficiency frontier, but without improving HIV/AIDS outcomes) [31]. In order to estimate true global resource needs accurately, both under financing and over financing need to be taken into account. Thus, a key limitation of the production frontiers model is that it does not directly measure the effectiveness of countries' HIV/AIDS activities.

A third challenge is the implicit assumption of the model is that by increasing financial assistance to low performing countries, the impact of their HIV/AIDS activities will increase. However, it is uncertain whether or not HIV/AIDS prevalence can be addressed just by closing existing funding gaps.

Costing Models in Water Supply and Sanitation

Analysts in other fields have confronted the challenge affecting HIV/AIDS—estimating the resources required to achieve the corresponding MDGs. The literature is particularly extensive for Target 10 of the Millennium Development Goals (MDGs) --water supply and sanitation. Target 10 calls for halving by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation. The year 1990 is considered the base year for this goal.

A recent review identified 11 original studies of the costs of meeting MDG 10—all by respected experts or organizations[32]. It appears that all the original studies used a similar costing methodology: multiplying the per capita cost of each type of water or sanitation technology by the size of the population receiving it. The strength of this work is that extensive

experience in the construction and operation of water supply programs provides a substantial empirical base for these unit costs. Also, the intensity of intervention (number of people covered) is relatively easy to calculate for MDG 10. Because different systems are in different locations, the assumptions about independence are plausible and simplify the calculations.

Water supply and sanitation differ from HIV/AIDS, however, in the importance of investment (capital) costs in relation to operating costs. Capital costs include planning and supervision, hardware, construction and house alteration, protection of water sources and education, and so on. Hutton et al estimated the cost primarily focusing on the capital cost based on the investment cost per person and the target population in need. They estimated the recurrent cost as a percentage to the annual investment cost from the literature, accounting for the system deterioration[33]. A similar model has been adopted in estimating the financial needs in Eastern Europe, Caucasus and Central Asia (EECCA) Region, one feature of which is that the unit cost is differentiated by the size of settlement[34]. Compared to HIV/AIDS control, the MDG Target 10 is clearer and measurable in terms of the number of population, and the interventions for water supply and sanitation are less intertwined.

One useful implication from the literature on water and sanitation is an appreciation for considering the sustainability of interventions (i.e., ensuring the continued maintenance and operation of water and sanitation systems). Another is an understanding of the impact of external changes on the cost of achieving an MDG, such as increasing urbanization and rising populations.

The eleven studies of Target 10 found a range in annual global costs from \$9 billion to \$30 billion. Causes for this variation included problems in defining key terms in the target, such as “safe” water and “basic” sanitation, limitations in available data, and varying assumptions about the levels of service required for water supply and sanitation and the associated unit costs[32].

Conclusion

While the UNAIDS Resource Needs Model is the only comprehensive approach to resource estimation, it has a number of limitations. Other approaches, such as the ABC model, the GOALS model, and approaches used in other diseases provide useful insights but do not offer comprehensive approaches. New models are likely to require the application of new techniques not previously needed in resource estimation, and/or the combination of the best features of several models.

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