Novel and Alternative Approaches to Estimate Global Resource Needs to HIV and AIDS

By

Donald S. Shepard, PhD

Wu Zeng, MD, MS

Matthew J. Neuman, MS

Angelique K. Rwiyereka, MD

Carlos Avila-Figueroa, MD

Schneider Institutes for Health Policy

Heller School

Brandeis University

Waltham, MA 02454-9110 USA

Email: Shepard@Brandeis.edu

Tel: +1-781-736-3975

Supported by

UNAIDS

Geneva, Switzerland

June 29, 2007

Abstract

National governments, donors, and international organizations are all anxious to forecast the resources needed to HIV AIDS in low and middle income countries. A review of existing approaches identified only one existing comprehensive approach, UNAIDS resource needs model (RNM). While this approach is clear and feasible to implement with existing data, it provides little insights about the efficiency of existing national programs nor how best to extrapolate from their experience. This paper proposes two new approaches forecast resource requirements.

The first technique, data envelopment analysis (DEA), has minimal data requirements. It could be used to determine which countries are most efficient in addressing HIV/AIDS (i.e., achieving specified levels of target outputs with minimal inputs), and to examine gaps (instances where a country's coverage or output is below the target). We show how such a performance gap could be apportioned between a resource gap (i.e., inadequate funding for HIV/AIDS activities) and an efficiency gap (i.e., fewer services being delivered with available resources in comparison to other countries).

The second technique is a combination of the World Bank's ABC Model (designed for modeling prevention), the GOALS model (which examines treatment and care), and the costing model used in water supply and sanitation (for costing program activities). If the requisite data are not available in the scientific literature, these techniques can be adapted to use expert panels. This technique not only estimates a country's resource needs, but also suggests proposed resource allocation that most efficiently address prevention of HIV/AIDS.

In conclusion, DEA can identify which countries are efficient and extrapolate findings from efficient countries; the more data intensive combination model can identify which prevention practices are most efficient within a country.

Introduction

National governments, donors, and international organizations are all anxious to forecast the resources needed to HIV AIDS in low and middle income countries. A review of existing approaches identified only one existing comprehensive approach, UNAIDS resource needs model (RNM). While this approach is clear and feasible to implement with existing data, it provides little insights about the efficiency of existing national programs nor how best to extrapolate from their experience.

In this paper, we present two complementary novel resource estimation methods to estimate global resource needs, building on lessons derived from the previous review and suggest a refinement to the main approach currently in use by UNAIDS. Our first proposed resource estimation technique, data envelopment analysis, draws from related techniques, such as linear programming. It is well suited for application at the global level. It allows comparison of many countries, while minimizing the amount data required about each country. It could be considered a top down approach, in that it could be implemented with data from an international agency.

The second is extension of the ABC model by incorporating the concept from costing model and GOALS model. The model is no long restricted in resource estimation for HIV/AIDS prevention, but is extended to the treatment, care, and program cost as well. It possesses the potential advantages of the ABC model, estimation based on solid current scientific evidence. It has the flexibility in resource estimation to adjust to the political concern and intervention prioritization on other criteria. Essentially, this model can be regarded as a bottom up approach, require detailed data at intervention level from the country.

Both approaches could be used simultaneously and would complement one another. The extension of ABC model provides the detail to ensure that the best indicators are chosen by the global model while the global model ensures that activities are classified and measured in ways that are internationally consistent.

Data Envelopment Analysis (DEA)

Data envelopment analysis (DEA) is a mathematical technique for identifying efficient production units, such as hospitals, factories, or companies, and quantifying the efficiency of each production unit. As DEA is derived from linear programming, we first describe this parent technique.

Linear Programming (LP): the origin of DEA.

Linear programming (LP) is a mathematical technique that finds the optimal combination of "activities" for a program. The goal can be expressed in either of two ways. One expression is to maximize an objective given specified input constraints. A complementary approach is to minimize cost while producing given quantities of specified outputs.

In applying LP to HIV/AIDS, both the maximization and minimization specifications could be used. The maximization objective could be the health gain measured, say as “DALYs” gained, through prevention and treatment. The activities would be detailed specifications of each of the components of a national program, such as voluntary counseling and testing (VCT), activities around prevention of mother to child transmission, treatment of infected adults, support of orphans, strengthening laboratory capacity, strengthening surveillance, etc. Constraints would be the capacities of existing health institutions and infrastructure, health professionals, and the political system.

The minimization specification would specify required levels of prevention and treatment and solve the system to minimize the cost of achieving these. One of the strengths of this approach is that alternative approaches to a different type of activity could be included. For example, a medical model of VCT might rely primarily on physicians, whereas a nurse model could rely more on nurses, and a community model could rely more on trained community workers. Quality levels could also be specified. A strength of this approach is its ability to examine substitutions among different types of health personnel in response to wages and availability in a country.

LP might possibly be useful to help countries address scaling up in view of constraints on skilled health professionals and senior managers. The approach would test the extent to which training of other types of health personnel are useful, and would allow the need and scale of training programs to be estimated. It would also see whether new management approaches could ease the administrative burden on governments and non-governmental organizations in running programs and generating the required activity and financial reports required by sponsors. Because of data constraints and strong assumptions of linearity, however, we see LP less as an approach to be used alone, but more as the conceptual origin of DEA.

Background on DEA

First put into practice by Charness et al. (1978), DEA resembles LP in so far as it measures the relative efficiency of programs or organizations. However, unlike LP (which tends to require in depth data), DEA focuses only on the most basic input components necessary for achieving a specific output. In order to add precision to the estimates, efficiency in DEA is generally measured as the weighted sum of outputs (the numerator) relative to the weighted sum of inputs (the denominator). Thus, DEA is an extremely versatile and relatively flexible estimation technique. DEA models have been used thousands of times to measure efficiency in a variety of contexts (Chilingerian, J. & Sherman, H.D., 1990; Sherman, H.D., 1992; Chilingerian, J. & Sherman, H.D., 1997; Wu, T. & Fowler, J., et al., 2006).

Recently DEA has been applied to several topics HIV/AIDS research. DEA has been used by researchers seeking to evaluate and identify best practices for HIV/AIDS treatment among several public hospitals in Kenya (Kirigia, J., Emrouznejad, A., & Sambo, L., 2004), as well as with district hospitals in Namibia (Zere, E., et al., 2006). The technique has also been used to develop a prediction model in order to analyze potential changes in anti-retroviral (ARV) treatment efficiency over time in China (Fuping, B., Liying, C., & Lessner, L., 2004). These studies demonstrate that DEA can be useful in identifying efficient and inefficient program-level attributes, as well as the "frontier" of HIV/AIDS program best practices. Thus, we propose using DEA to conduct efficiency comparisons of HIV/AIDS activities both between and within countries, and extend it to the resource estimation.

Application of DEA to Resource Estimation for Achieving MDGs or UNGASS goals

DEA could be applied towards estimating the resource needs for achieving those United Nations Millennium Development Goals (MDGs) that relate to HIV/AIDS and/or the goals of the 2001 United Nations General Assembly Special Session on HIV/AIDS (UNGASS). In order to do this, it will be necessary to estimate the coverage for several HIV/AIDS broad activities that relate to achieving either the MDG or UNGASS goals. These activities fall under three main categories: treatment, prevention, and operations and support.

As described above, DEA has minimal data requirements. At a minimum, the user must specify input and output quantities for each decision making unit (DMU). The scope and level of detail of these input and output measures can vary, either due to the availability of data, and/or the level of precision desired by researchers, their supporters, or the scientific community as a whole. Detailed country-level information on both HIV/AIDS treatment, prevention, and/or operations and support activities inputs (i.e., support - spending or funding) and/or outputs (i.e., outcomes, coverage, prevalence, etc.) are generally only available for a limited group of countries. When country-level input and output data on the three main HIV/AIDS activity categories are available, they are generally reported in the aggregate. An advantage of DEA is that it can analyze aggregated data. For this reason, we feel that the technique offers a promising first step towards identifying novel methods for estimating global resource needs for combating HIV/AIDS.

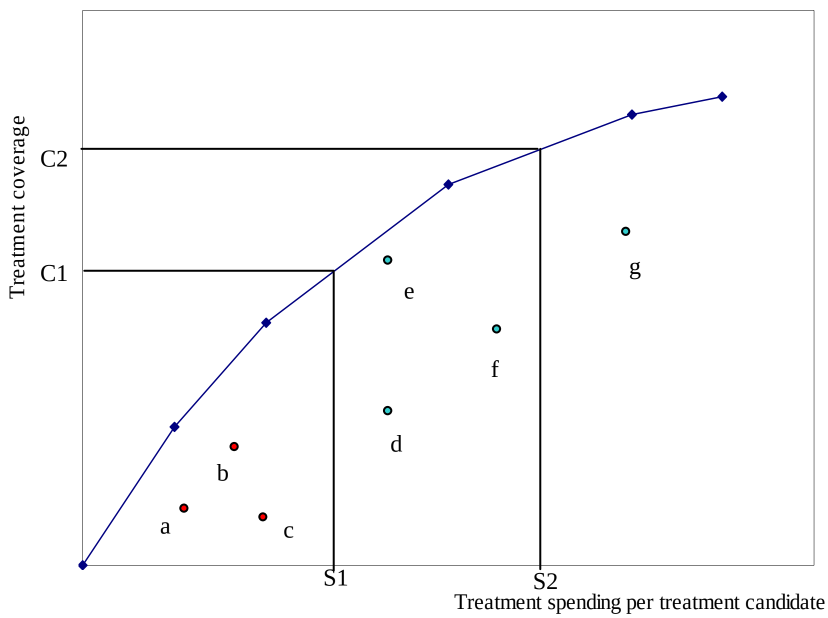
To begin the process of estimating global resource needs for HIV/AIDS, we recommend using coverage-levels in relation to the UNGASS goals or MDGs as a output measure, such as coverage of VCT, ARV treatment, for OVCs, etc. Because of the differing goals and resource needs of global HIV/AIDS programs, we would suggest that spending be divided into two components: prevention and "care." Care comprises both treatment and OVC support. Program activities would be allocated pro-rata between prevention and care based on the share of service costs used by prevention compared to care.

The aggregate input measures we recommend would be spending on HIV/AIDS prevention or care. These measures could focus either on HIV-related prevention, treatment, or support, AIDS-related treatment or support spending, or OVC-related spending. Provided the data were available, more detailed input measures could be explored including durable and non-durable items spending, human resources spending, education and training costs, human as they each relate to the three main categories.

The following is a general overview of how DEA could be applied to HIV/AIDS resource need estimation on a country-level. For this example, we express the input measure in terms of treatment spending per treatment candidate (S), with coverage-levels of AIDS treatment as our output measure (C) using several hypothetical countries. Similar to Production Frontier Analysis models, a frontier of C (AIDS treatment coverage) in terms of S (AIDS treatment spending per treatment candidate) can be detected (see Figure 1). In this hypothetical example, examining C relative to S using DEA can be useful in identifying high and low performers, as well as best and worst practices. Since DEA estimates relative efficiency, the results of our model either suggest technical, allocative, and/or productive solutions. For instance, in our example DEA could be used to set coverage and/or spending targets.

For example, suppose that a target coverage goal for AIDS treatment was C1. The corresponding spending in need of treatment for an efficient country would be S1. Notice that in this example, three hypothetical countries a, b, and c, are spending less relative to the best performing country while remaining far below the target coverage-level (C1). Countries a, b, and c might be performing well in terms of coverage, especially considering that their AIDS treatment activities are likely underfinanced, but additional funding might help these countries scale-up their AIDS treatment coverage-levels. Similar to Production Frontier Analysis models which Preker and Flavia Bustero et al. (2005) have used for estimating the cost to achieve several MDGs, DEA can be used to estimate the necessary spending for closing the gap between current levels of spending and C1. For those countries who in our example spent more than S1, but still fell below C2 (i.e., countries d, e and f), a solution aimed at improving performance through bolstering technical, production, and/or allocation efficiency might be more prudent than additional funding. It should be noted that because DEA uses the best performer or most efficient country as its reference, its estimates are still only the minimal resources required to achieve the specified goal. Further analysis will likely be required to identify the true source of inefficiency.

Figure 1: Hypothetical DEA model: Coverage of AIDS treatment versus spending per treatment candidate by country for a single year



A refinement of DEA could subdivide spending into donor-funded spending and domestic public spending. The distinction would be important if there were different constraints on the way each type of funding could be used. For example, for a major program funded by the US government, the President's Emergency Fund for AIDS Relief (PEPFAR) "…Congress mandated that 55 percent of funds go for treatment, 20 percent for prevention, 15 percent for "palliative care" to relieve pain including at the end of life, and 10 percent to assist orphans and other children affected by the pandemic." [10].

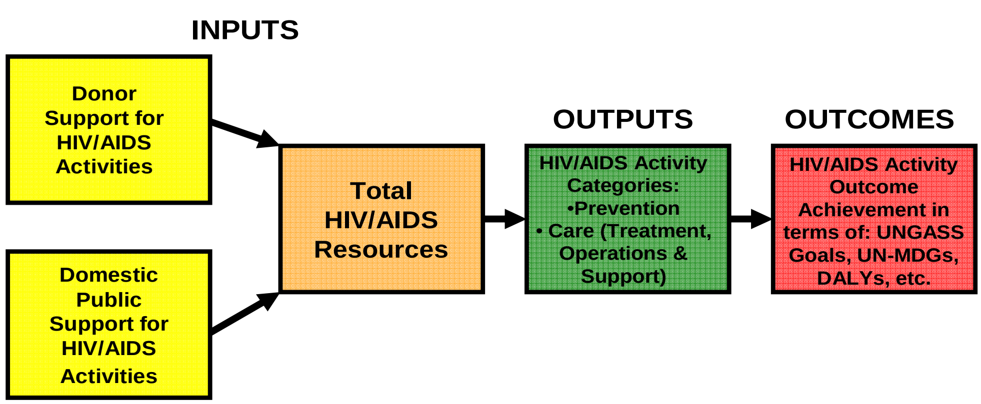
The population size and the prevalence of HIV/AIDS in the country have strong effects on the calculation of efficiency. DEA can incorporate and control for these factors as "non discretionary inputs" when calculating DEA models.

Spending needs to be based on a single international currency. The preferred measure is likely to be international dollars, in which actual dollars are converted based on purchasing power parity (PPP) to take into account the differential buying power of one dollar in different countries.

DEA for Estimating the Relative Efficiency of a Country's HIV/AIDS Activities

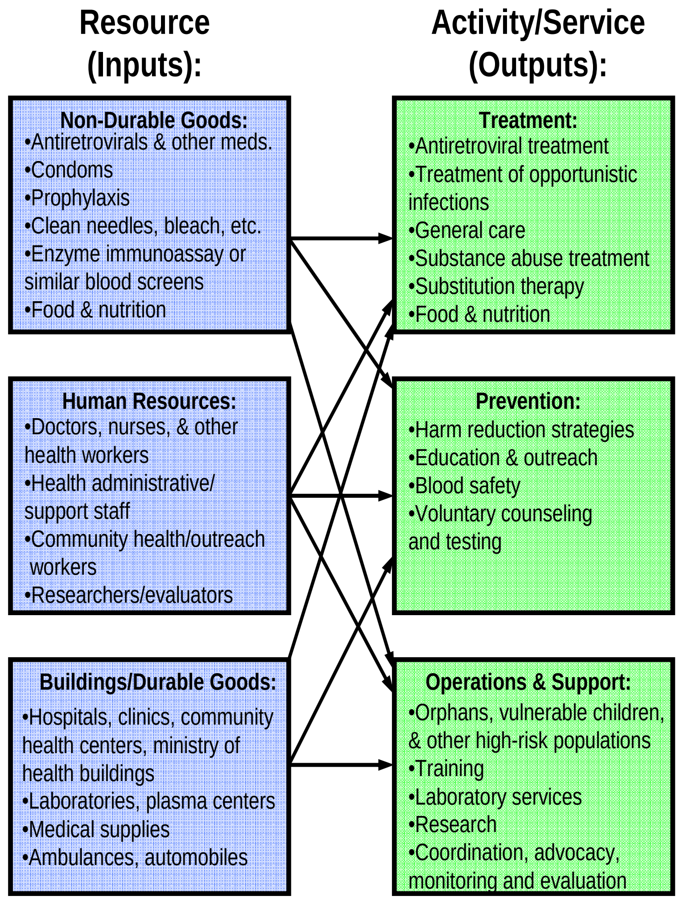
DEA can also address a number of other important policy questions. Depending on data availability, time and/or research resource constraints, DEA comparisons could be used for either inter-country comparisons (adjusting for population size and purchasing power parity per capita GNP), or within country analyses. We propose that DEA might first be used to make inter-country comparisons among HIV/AIDS treatment and care. As shown in Figure 2, DEA could be used to estimate the ratio of the effectiveness of a country's HIV/AIDS response (measured as the total new HIV infections averted in Disability Life Years Averted—DALYs—and number of individuals receiving AIDS treatment) or in terms of achieving the UNGASS goals or MDGs, to the country's overall HIV/AIDS spending or funding (including domestic, foreign, individual, public and private contributions). It should be noted that unlike elasticity measurement, DEA does not assume that an input measure has a constant variance. Rather, DEA can identify inefficiencies due to unequal levels of health system resources, infrastructure, service and support, and/or absorptive capacity within countries. With this in mind, efficient countries would have smaller ratios relative to comparable countries or else DEA would deem more costly HIV/AIDS treatment, prevention, and/or operations and support activities to be relatively less efficient. For example, an effective HIV treatment program might facilitate a measurable decrease in AIDS-related mortality by providing ARV treatment and/or supporting prevention activities. However, if a comparable decrease is achieved by another similar sized country, but using fewer resources, then the more fiscally efficient country's program would be deemed superior.

Figure 2: DEA Framework for Estimating Efficiency of HIV/AIDS Prevention & Care Activities Between Countries



It would be challenging and extremely costly to conduct HIV/AIDS resource needs assessments for every low- and middle-income country in the world. A macro-level DEA analysis could, however, be followed up by more micro-level ones conducted in those countries whose programs are deemed efficient (or inefficient). In other words, those countries could be subjected to more detailed DEA analyses in order to identify specific factors that might be contributing to the HIV/AIDS activities being particularly efficient (or inefficient). For example, instead of support for HIV/AIDS activities, specific resource inputs like non-durable goods (e.g., antiretroviral medications, condoms, etc.), human resources, and health system infrastructure (e.g., buildings and other durable goods could be assessed. HIV/AIDS outputs could also be further disaggregated into three broad service/activity categories: treatment, transmission, and education, prevention and awareness. Figure 3 illustrates the pathways of these micro-level input and output categories, as well as some specific items within the six broad categories that could be assessed as part of a country level DEA. A within-country analysis might entail making comparison between comparable input and output category items. Once the data requirements are specified, spreadsheet software could be employed to capture the specific cost, utilization, or capacity data for the comparisons. Such analyses could be used to compare the relative efficiency of HIV/AIDS activities by region or, perhaps, even by township. Similar to the macro-level DEA, the overarching goal of the country-level analyses will be to determine the gold standard for HIV/AIDS treatment and prevention services/activities within specific countries. These findings might also have important implications outside of the country by revealing the formula for how successful programs maximize HIV/AIDS resources, while reducing overall rates of HIV infection and/or AIDS-related mortality.

Figure 3: A DEA Framework for Estimating Efficiency of HIV/AIDS Prevention & Treatment Activities within Countries



DEA for Identifying Socio-economic and Cultural Barriers to HIV/AIDS Activities

Funding for HIV/AIDS programming surpasses that for any other infectious disease, yet it tends to be a very sensitive and highly politicized issue. This is at least partially due to the fact that HIV/AIDS prevalence tends to be intertwined with larger social and cultural problems and trends stemming from government corruption, poverty and limited economic opportunities, as well as bigotry. Signals of these broad problems may include weak health systems/structures, prostitution and drug addiction, widespread violence and/or war, and various social inequalities including: misogyny, homophobia, racial and/or ethnic prejudice, etc. While these socio-economic and cultural issues can be reasonably easy to identify, they are often quite difficult to address. When it comes to HIV/AIDS, it is clear that policymakers need to be proactive, vigilant, and open-minded. Countries with inflexible or intolerant attitudes towards HIV/AIDS sufferers (or those who are at risk of becoming infected), will likely require more than restructuring of their health systems or increased funding. DEA might prove valuable for policy makers who seek to identify countries with socio-economic and cultural problems that impact their HIV/AIDS activities. In those cases where DEA determines that a country's health system has adequate infrastructure and/or sufficient funding in place, but is still inefficient in its HIV/AIDS response, socio-cultural and/or economic risk factors should be explored.

Advantages of Using DEA

Applying DEA approach to resource estimation has several advantages compared with the current approaches. First, the existing methods show that the biggest constraint in estimating the resource needs accurately is data availability. The ABC and ,GOALS models both require substantial amounts of country-specific information, especially detailed program level data, which are difficult to assemble. By contrast, the data needs of DEA are much more modest. The approach is analogous to the use of the hedonic prices method to estimate the economic values for ecosystem, if we regard a country as an ecosystem which all activities of prevention, treatment of HIV/AIDS, care of orphans, and so on. In this way, the data requirement is reduced substantially.

Second, all these three models estimate the financial needs by intervention. Less consideration is given to the synergetic effect among interventions. The DEA approach focuses on the cost for the most efficient counties to achieve the target, in some degree, can be regarded that the combination of the interventions is optimal. The synergetic effect is not estimated separately across interventions, but will be showed as a whole from the minimal inputs from the most efficient country, such as the prevention spending per capita, at specified levels of outputs.

Third, the DEA approach, essentially demonstrates optimal resource estimation. As we mentioned before, the ideal model should include optimization to ensure that the required inputs and the lowest needed to achieve the chosen mixture of goals. Both international and domestic donors would like to spend every dollar in where it should go to combat HIV/AIDS effectively and efficiently. Minimization of the cost to fulfill the specified target should be incorporated in the model in terms of the evaluation of the effectives and efficiency of the interventions. The further sensitivity analysis would be more informative for resource estimation in response to the real performance of the countries, which leads to a more reasonable and practical estimation.

DEA as an Approach to Analyze Gaps

Policymakers are concerned with three types of gaps: performance gaps, resource gaps, and efficiency gaps. Performance gaps refer to the difference between current performance and internationally agreed goals, such as the MDGs or UNGASS goals. Performance gaps (PG) may be due to either or both of the other two gaps. Resource gaps (RG) refer to the difference between the resources needed to fully implement an efficient program and those available. Efficiency gaps (EG) indicate the difference in a country's performance with a given level of resources compared to those achievable with the same resources if the country were optimally efficient.

DEA and elements of frontier analyses can be applied to estimate the magnitude of each of these gaps. DEA can also help identify the barriers and favorable factors in a country for strengthening its efforts against HIV/AIDS. Figure 4 shows an example of these three gaps.

Figure 4. Analysis of gaps for hypothetical country X

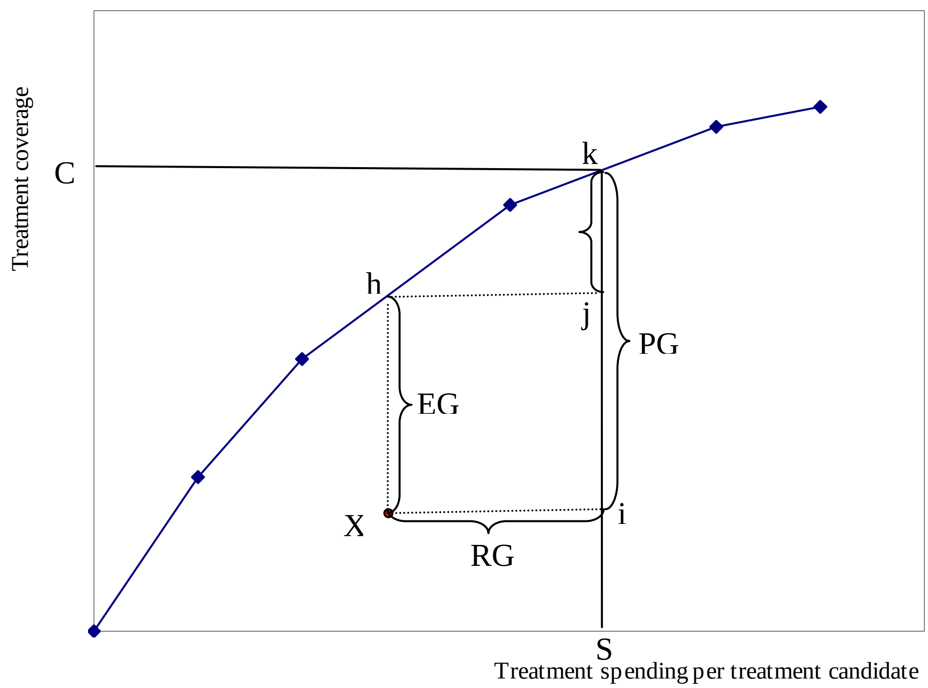


Figure 4, derived from Figure 1, shows a production frontier estimated from hypothetical data. The HIV/AIDS target is a specified coverage, C, of a critical service such as the percentage of eligible patients on antiviral treatment. The country that achieves this target efficiently is represented by point k; it lies on the production frontier and spends the amount S per treatment candidate, an amount that is just sufficient.

Now consider a hypothetical county X, which is neither achieving the coverage goal C, nor committing sufficient resources to the activity. Country X is regarded as an inefficient country because it lies below the point h on production frontier. To fulfill the target of C, S is the corresponding treatment spending in the most efficient country. Thus, the horizontal distance *Xi* represents the resource gap (RG) of country X in dollar amount per treatment candidate. This resource gap shows that even if country X were efficient, it could not reach the goal C partly because of lack of resources. Next, the distance *Xh,* or the equivalent distance *ij.* represents the efficiency gap (EG) given a specified level of inputs. This gap indicates that if country X were maximally efficient, it would improve its performance to reach the coverage level of *h*. Finally, the total performance gap (*PG)* of country X can be represented by the distance of *ik* in term of the treatment coverage. The component corresponding to the distance of *jk* indicates the degree of expansion of treatment coverage achieved by filling the resources gap. These gaps can be monitored dynamically with multiple years of data. Even if the program of country X could not be made optimally efficient, then it could still reach the target coverage, C, but it would require additional resources, beyond the level S, to compensate for its inefficiency.

Through qualitative analyses of country performance and monitoring changes in these gaps over years, lessons can be learned about ways in filling different gaps and improving the efficiency for HIV/AIDS programs. The dynamic analyses should provide important policy guidance for HIV/AIDS control.

These analyses can readily be extended from an individual country, X, to the global level. Conceptually, total global resource needs could be calculated using this combination of DEA and the production frontiers model by the summing resource needs of each country. If the country's program were completely efficient, the resource needs would correspond to S in Figure 4. If the country were not completely efficient, additional resources would be required. Finally, this approach can be used not only to estimate absolute resource needs, but also incremental needs, where the increment is the difference between requirements and existing commitments.

DEA Data Requirements for Estimating Global Resource Needs and Gap Analyses

DEA is particularly useful in situations where there are multiple outputs and inputs to each "decision making unit" (DMU). As noted previously, a major advantage of DEA is the limited number of data items required of each DMU. If the DMUs were countries, as envisioned here, the data requirements consist of the input and output quantities for each country. Fortunately, many of the required items of output data are monitored and reported annually by country. One good example for low and middle income countries is the UNAIDS report in 2006 with supplemental data on key interventions, on coverage of key services, such as VCT, ART treatment, AIDS education, PMTCT, and condom distribution (UNAIDS, 2006; Stover, J., M. Fahnestock., 2006).

Regarding input data, the "non discretionary inputs," population size and the prevalence of the HIV/AIDS, are relatively easy to acquire. However, obtaining spending on macro-categories of interventions, such as prevention, treatment, care, and program cost, may impose a great challenge in apply DEA in resource estimation. The availability of data is complicated by the fact that there are generally multiple funding sources within countries including: individual out-of-pocket expenses, domestic governmental support, assistance from foreign governments, multilateral donor institutions (such as UNAIDS, the World Bank, PEPFAR, and the Global Fund), NGOs and self-funded non-profit organizations (Partners in Health), and private foundations (the Clinton Foundation, the Bill and Melinda Gates Foundation, etc.).

Fortunately, some countries, Brazil, Guatemala, Honduras, Mexico and Uruguay as examples, have done the national HIV/AIDS sub-accounts, spending could retrieve from these articles (Izazola-Licea JA, Avila-Figueroa C, Aran D, et al., 2002), although we need to concern about the time concordance when matching cost or spending data with service coverage data. More promising, UNAIDS is currently working on assembling spending data from the countries, which potentially enable DEA to be the first method using real data in estimating resource need for HIV/AIDS control without strong assumption restrictions. We strongly recommend UNAIDS to explore this approach further whether in resource estimation, gaps analysis, and determinants analysis in efficiency.

Proposed Combination Model

By reviewing ABC Model, GOALS Model, and Costing Model for water supply and sanitation, we realized that each model distinguishes itself by its salient feature in different settings. For example, ABC model is useful in modeling with the cost for prevention, The GOALS model includes the interventions for policy environment and the treatment in the model, and the models that applied in water supply and sanitation provide methods for estimating the resource needs for capital investment. A combined method may produce a reasonable and feasible estimation of overall resource need in HIV/AIDS control, including prevention, treatment, care and support of orphans and venerable children (OVC), program cost, and others.

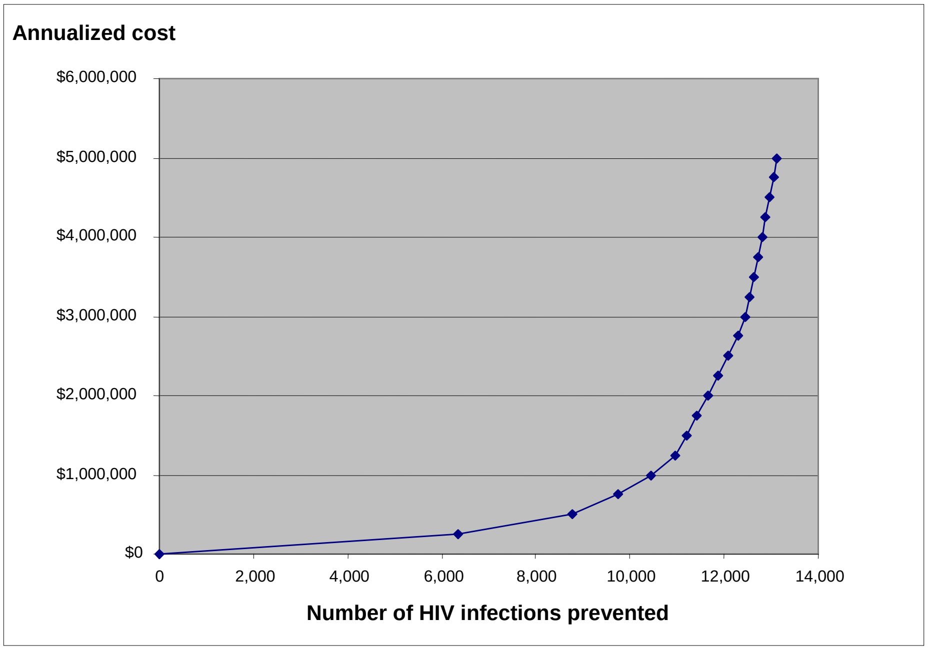
The combined method we propose is derived from the ABC Model. The ABC model could be extended to estimate the minimal cost requirement for prevention given the expected number of averted infections, based on prioritizing the most cost- effective interventions. A national cost function could be produced, showing the cost to avert a specified number of infections, assuming that resources are allocated optimally.

Figure 5 illustrates this process with actual data from the application of the ABC model to Honduras. Since this cost function is derived from the ABC model, its advantages and disadvantages are essentially those of the ABC model itself. Thus, as strength, the cost function can include changing the priority of the interventions based on other criteria, such as equity and policy concerns. Incorporating such changes will also change the shape of the cost curve. Also, by using this model, we not only find the cost to achieve the goals, but can also understand where the resource should go.

The cost function has the same limitations as the ABC model: It does not consider interactions among the interventions, it does not apply to the treatment, care and support, and program operation, and it is very sensitive to assumptions about effectiveness of interventions.

One way of overcoming the exclusive focus on prevention is to combine prevention and treatment components. This can be done by changing the target indicator of number of averted infections into indicator of the health gain measurement, such as disability adjusted life years (DALYs) gained from prevention and treatment. The same process would follow. First, the extended model would use the ABC model to retrieve the DALYs gained from each intervention at different budget level. Then, it prioritizes the interventions (including treatment and prevention) with largest DALYs gained given certain budget. Based on information of budget and health gained, it builds a cost curve similar to Figure 5. Last, it could adjust the cost function according to other concerns that the policy makes may have.

Figure 5. National cost curve derived from the application of the ABC model to Honduras



Data source: Optimizing the allocation of resources among HIV prevention interventions in Honduras. June, 2002.

Another option is to build a separate model for treatment, and care and support for OVC, since the target population for treatment and OVC is more homogenous, and the choices of interventions for them is more limited in contrast to the prevention. Another reason to use another model for treatment and care of OVC is that there is a clear and measurable target for them supplemented by other document---universal access to treatment, and care of 80% of children most in need with basic services by 2010 (UNAIDS, 2006).

The analysis of program cost could be refined by employing the concept from the models in the water supply might be an applicable strategy, which focuses on estimating cost of interventions accounting for largest share of the budget, and estimates the minor cost as the percentage of the major cost categories. In HIV/AIDS, consumables and service delivery, such as antiretroviral drugs, condoms, needles, and so forth, represent a substantial share of budget; thus, many studies considered only on the cost for service delivery and excluded "program" costs, such as management, training, research and evaluation, and capital investment. The National Costing Model, below, has adopted this approach.

References

1. Charnes, A., Cooper, W.W., and Rhodes, E. (1978). Measuring the efficiency of decision-making units", European Journal of Operational Research 3, 429-444.
2. Chilingerian, J.A., and Sherman, H.D. (1990). Managing physician efficiency and effectiveness in providing hospital services, *Health Services Management Research*, 3(1), 3-15.
3. Chilingerian, J., & Sherman, H.D. (1997). DEA and primary care physician report cards: Deriving preferred practice cones from managed care service concepts and operating strategies. *Annals of Operations Research*, 73.
4. Fuping, B., Liying, C., & Lessner, L. (2004). DEA-based Anti-HIV Immunotherapy Model. *Progress in Natural Science*, 14(9).

5. Preker AS, Flavia Bustero ES, et al (ed.): Financing the Millennium Development Goals. Expenditure Gaps and Development Traps. World Bank; 2005.

6. Kirigia, J., Emrouznejad, A., & Sambo, L. (2004). Using data envelopment analysis to measure the technical efficiency of public health centers in Kenya. *Journal of Medical Systems*, 28(2): 155-166.

7. Sherman, H.D. (1992*).* Data Envelopment Analysis (DEA): Identifying New Opportunities to Improve Productivity. *Tijdschrift voor Economie*, XXXVII, 2.

8. Wu, T. & Fowler, J., Calarman, T., Moorehead, A. (2006) Multi-stage DEA as a Measurement of Progress in Environmentally Benign Manufacturing, *Flexible Automation and Intelligent Manufacturing*, Limerick, Ireland.

9. Zere, E., Mbeeli, T., Shangula, K., Mandlhate, C., Mutirua, K., Tjivambi, B., Kapenambili, W. (2006). Technical efficiency of district hospitals: Evidence from Namibia using Data Envelopment Analysis. *Cost Effectiveness and Resource Allocation*, 4; 5.

10. Reichard, J. (2007). Institute of Medicine Urges Changes in U.S. Global AIDS SpendingCQ HEALTHBEAT NEWS. March 30, 2007, http://public.cq.com/docs/hb/hbnews110-000002482722.html

11. UNAIDS; Report on the global AIDS epidemic. 2006.

12. Stover, J., M. Fahnestock. Coverage of Selected Services for HIV/AIDS Prevention, Care, and Treatment in Low- and Middle-Income Countries in 2005. Washington, DC: Constella Futures, POLICY Project. 2006.

13. Izazola-Licea JA, Avila-Figueroa C, Aran D, et al.; country responses to HIV/AIDS: national health accounts on HIV/AIDS in Brazil, Guatemala, Honduras, Mexico and Uruguay. AIDS. 2002 Dec;16 Suppl 3:S66-75.

14. UNAIDS; Considerations for countries to set their own national targets for HIV prevention, treatment, and care. April 2006.