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Title: Seeking the efficient purchase of non-health benefits using the extended cost-effectiveness analysis (ECEA) methodology

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Abstract:

Health policies such as public finance of health interventions entail consequences in multiple domains. Fundamentally, health policies increase uptake of interventions and hence lead to health benefits. However, in addition, health policies can generate non-health benefits including for example the enhancement of equity (e.g. equalization of health among individuals) and the prevention of medical impoverishment – or the provision of financial risk protection. This paper details how the methodology of extended cost-effectiveness analysis (ECEA) can be used for evaluating the consequences and benefits of health policy in both the health and non-health (e.g. equity, financial risk protection) domains.

1. Introduction

Multiple criteria are involved in decision-making and prioritization of health policies [1]. The trade-offs between efficiency and equity are among these criteria, and have long been emphasized in the field of HIV/AIDS treatment and prevention for example [2-4]. Notably, several mathematical frameworks, including mathematical programming, have proposed to incorporate equity considerations into resource allocation in the public sector [5-9].

Protection from financial risks associated with healthcare expenses is emerging as a critical component of national health strategies in many low- and middle-income countries. The World Health Organization's (WHO) World Health Reports of 1999 and 2000 included provision of financial risk protection (FRP) as one criterion of good performance for health systems [10,11]. The reduction of these financial risks is one objective of health policy instruments such as universal public finance (UPF) – full public finance irrespective of whether services are provided privately or publicly. Indeed, out-of-pocket (OOP) medical payments can lead to impoverishment in many countries with households choosing from among many coping strategies (e.g. borrowing from peers/relatives, asset selling) in order to manage health-related expenses [12-14]. Absent other financing mechanisms, like private health insurance, household medical expenditures can often be 'catastrophic' [15,16] – defined as exceeding a certain fraction of total household expenditures.

Health policies such as UPF of health interventions entail consequences in multiple domains. Fundamentally, health policies increase uptake of interventions and hence lead to health benefits (e.g. deaths averted). However, in addition, health policies can generate non-health benefits including for example the enhancement of equity (e.g. equalization of health among individuals in a given population), the prevention of medical impoverishment – or the provision of FRP.

Traditionally, economic evaluations of health interventions (cost-effectiveness analysis or CEA) have focused on health improvement and have estimated an intervention cost per health gain, in dollar per death averted or dollar per disability-adjusted life-year (DALY) averted [17]. Our goal in this paper is to detail the methods of extended cost-effectiveness analysis (ECEA) [18-21] which supplement traditional economic evaluation with non-health benefits (e.g. equity, FRP) evaluation, within the broader objective of providing valuable guidance in the design of health policies.ECEA in this respect builds on the existing frameworks of cost-benefit analysis and cost-consequence analysis tabulating disaggregated results [22], and on analytical frameworks incorporating equity and FRP concerns into economic evaluations [23-32]. It enables the design of benefits packages that quantifies both health and non-health benefits (e.g. equity, FRP) for a given expenditure on specific health policies, based on the quantitative inclusion of how much non-health benefits are being bought, as well as how much health benefits are being bought with a given investment on an intervention or policy. In this respect, ECEA can give answers to some of the policy questions raised by the World Health Reports 2010 and 2013 [33, 34] on how to select and sequence the health services to be provided on the path toward universal health coverage (UHC).

2. Methods

We consider the implementation of a given health policy *HP* in a given population *P*. *P* is subdivided into *n* sub-groups (e.g. per socio-economic status according to five income quintiles; per region according to distinct geographical locations; per gender), which we note P_k (with $1 \leq k \leq n$). *HP* presents a given coverage *Cov* and given effectiveness *Eff* on preventing disease burden *D* in the population as well as a net cost *C*. We assess both health benefits B_H and non-health benefits B_{NH} in *P* in what follows.

Health benefits

With the introduction of *HP*, health benefits B_H are procured which can be given, for example, by the sum of the burden of disease averted in each population subgroup P_k, as:

$$B_H = Eff \sum_{k=1}^{n} Cov_k D_k = Eff \int_P Cov_k D_k dP_k \quad (1)$$

when the effectiveness of the policy (*Eff*) is assumed to be constant per population sub-group (P_k). Note that we used in (1) a static formulation of the health benefits brought by the policy, for ease of exposition. In the case of infectious diseases, a dynamic transmission model could capture such health consequences, using a more complex mathematical formulation.

Non-health benefits

With the introduction of *HP*, non-health benefits $B_{NH,j}$ (with $1 \leq j \leq m$, where m indicates the type of non-health benefits (e.g. FRP, number of school days gained) are procured. For example, if the non-health benefit considered is FRP, given a preexisting burden of medical impoverishment (e.g. due to medical expenses, direct non-medical costs such as transportation costs, and wages lost) *MI*, the related non-health benefits could be expressed, for example, by the sum of the burden of disease-related impoverishment averted in each population subgroup P_k, as:

$$B_{FRP} = Eff \sum_{k=1}^{n} Cov_k MI_k = Eff \int_P Cov_k MI_k dP_k \quad (2)$$

Equity benefits

With the introduction of *HP*, equity benefits B_{Eq}, as estimated here in terms of health, can be procured. For example, if *HP* provides more health benefits toward poorer segments of the population than to richer segments of the population, the policy could be deemed ‘equity enhancing’. We quantify B_{Eq} in the following:

$$B_{eq} = \frac{B_{H,w}}{B_H}$$

$$= \frac{Cov_w D_w}{\sum_{k=1}^{n} Cov_k D_k} \quad (3)$$

where $B_{H,w}$ and B_H are the health benefits procured by *HP* among the worst-off group and the total sum of the health benefits in all the groups, respectively; Cov_w and D_w are the coverage of the health policy and burden of disease in the worst-off group, respectively.

Efficient purchase of health and non-health benefits

The net cost of the health policy is *C*, hence for that net cost *HP* purchases 'efficiently' health benefits B_H, but also non-health benefits B_{NH} (e.g. B_{FRP}, B_{Eq}). We can then naturally define, as in a traditional CEA, a usual incremental cost-effectiveness ratio (ICER) i.e. $ICER = C/B_H$, but we can also define an ICER for each of the non-health benefits, as for example: a) for FRP with $ICER_{FRP} = C/B_{FRP}$; and b) for equity with $ICER_{Eq} = C/B_{Eq}$.

As an example, Figure 1 displays both the deaths averted and FRP benefits (measured by a money-metric value of insurance), per income quintile, through UPF for rotavirus vaccination in India and Ethiopia.

[FIGURE 1 HERE]

3. Application

We now apply the ECEA approach in considering the example of UPF for tuberculosis (TB) treatment in a given population *P* composed of five income quintiles totaling of 1,000,000 people (with 200,000 people per each income quintile P_k), building on previously published work [18]. We assume an average incidence of TB of p_0 = 100 per 100,000 per year, with incidences of respectively 200, 150, 100, 50 and 0 per 100,000 in the five population sub-groups. TB treatment is assumed to be effective at 90% and current coverage is assumed to be 40% uniformly across each quintile. We assume a coverage increase of 10% equal across all five population sub-groups, through UPF. Case fatality rate from TB is assumed at 25%. In addition, before policy implementation, individuals who are TB-infected purchase TB treatment (40% of them) at *c* = $100 out of pocket and lose three months of wages; after UPF of TB treatment, they spend no money out of pocket though they still lose three months of wages because of sickness. Finally, we assume an income distribution in the population following a Gamma distribution based on a mean income of $1,500 and a shape of 3.5, as produced by an algorithm given by Salem and Mount [35].

The results for this example are listed in Table 1, for UPF to increase coverage to 10% of a population of 1,000,000. The total number of deaths averted would be about 90 per year. Table 1 exhibits the distribution of the deaths averted across different income quintiles: the health benefits would be concentrated among the bottom income quintile (40%) as TB is more incident among this income group. The total number of private OOP expenditures averted by the UPF program would be of about $40,000. The bottom income quintile would benefit from about 40% of the private expenditures averted. The total (incremental) treatment costs incurred by UPF would be about $50,000 ($40,000 + $10,000). The total FRP afforded by the UPF program is estimated here as the number of poverty cases averted (number of individuals no longer falling under a poverty line of say $607 of income including individuals in the bottom decile) would be about 34, all of which among the bottom income quintile. Furthermore, the equity benefits of the UPF program are given by 36 divided by 90 divided by 50,000 i.e. 8 per $1,000,000.

[TABLE 1 HERE]

Now, examining the efficient purchase of both health and non-health benefits, we find: $ICER =$ $520 per death averted, $ICER_{FRP} =$ $1,470 per poverty case averted, and $ICER_{Eq} =$ $125,000 per equity ratio. Per $1,000,000 spent, we obtain a total of 1,800 deaths averted, 720 of which among the bottom income quintile, and 680 poverty cases averted, all of which among the bottom income quintile.

[FIGURE 2 HERE]

4. Discussion

We presented in this paper detailed methods for the broader economic evaluation of health policies, which we name 'extended cost-effectiveness analysis' or 'ECEA.' ECEAs build on CEAs in assessing consequences in both the health and non-health domains (e.g. equity, FRP).

The ECEA approach permits the novel inclusion of non-health benefits (e.g. equity, FRP, school days gained, etc.) in the economic evaluation of health policies. The ECEA approach enables the inclusion of multiple criteria into the decision-making process. More importantly, the ECEA approach enables the design of benefits packages, such as health insurance packages, based on the quantitative inclusion of information of how much non-health benefits can be bought, in addition to how much health can be bought, per dollar expenditure on healthcare (Figure 3).

[FIGURE 3 HERE]

Some health policies will rank higher on one or another metric relative to the other. While this methodology does not advise on what to be selectively prioritized and included into a benefits package, it allows policymakers to take both health and non-health outcomes into account when making decisions and thus to more effectively target scarce healthcare resources toward specific policy objectives. For example, financial risk protection provided through risk pooling may be the rationale to include an intervention while a desire to increase coverage may be the rationale for another. Understanding this distinction can be critical to achieve either goal. The ECEA approach also provides policymakers information on how they might sequence the development of healthcare packages as the health and financial needs of populations evolve and resource envelopes change, which is especially relevant in the context of moving toward UHC.

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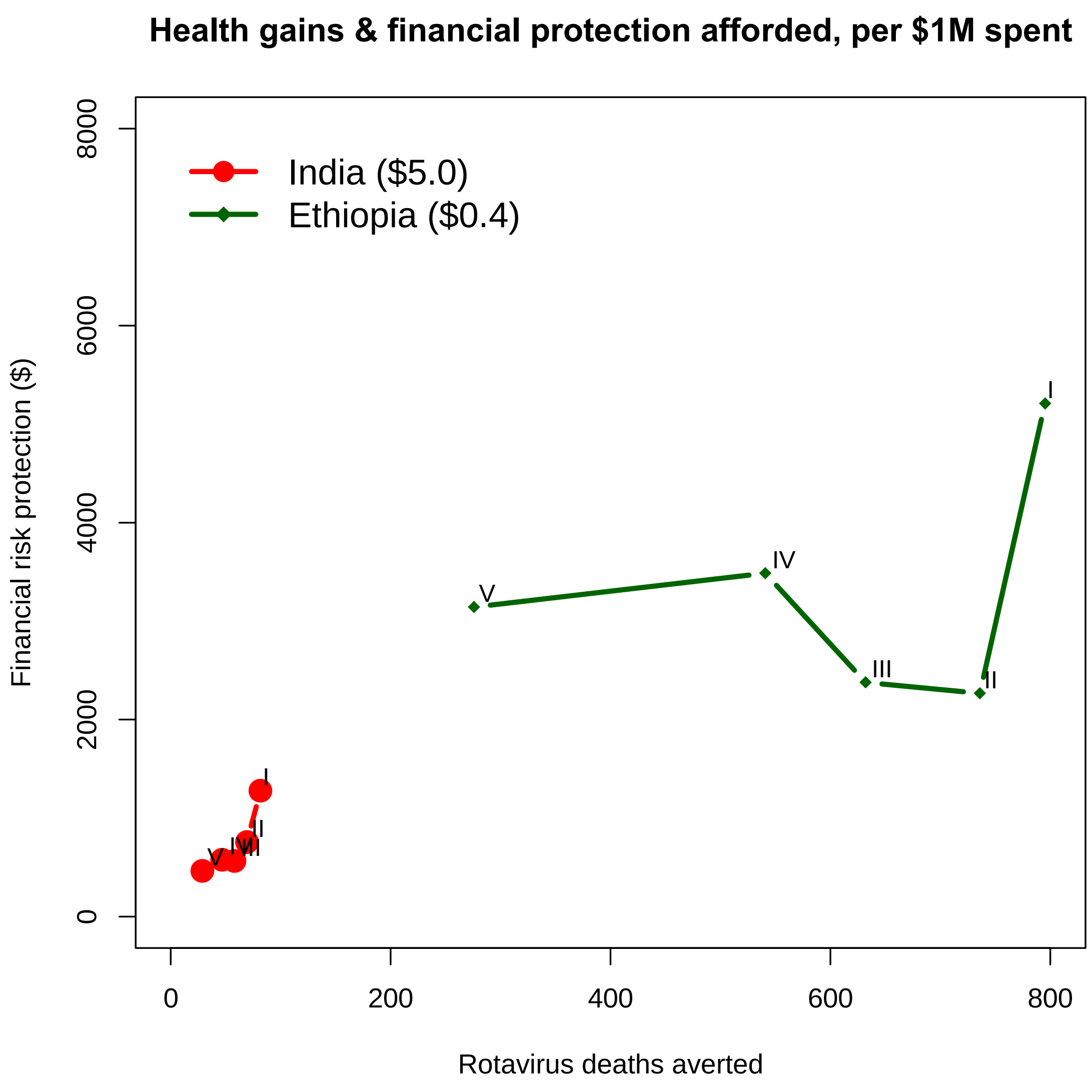
Tables and Figures

Table 1. Extended cost-effectiveness analysis (ECEA) results for universal public finance of tuberculosis treatment to 40 + 10% coverage (per million population)

Outcome	Total	Income Quintile I	Income Quintile II	Income Quintile III	Income Quintile IV	Income Quintile V
TB deaths averted	90	36	27	18	9	0
Private expenditures	40,000	16,000	12,000	8,000	4,000	0
Poverty cases	34	34	0	0	0	0

Figure 1. Deaths averted and financial risk protection afforded over five years with the introduction of universal public finance for rotavirus vaccination at current coverage of 2nd dose of Diphteria-Pertussis-Tetanus, per $1,000,000 spent, as a function of vaccine price, India and Ethiopia. Income quintiles: I = poorest, II = poorer, III = middle, IV = richer, V = richest.



Source: Verguet S, Murphy S, Anderson B, et al. Vaccine 2013 [19].

Figure 2. Deaths averted and poverty cases averted with the introduction of universal public finance for tuberculosis treatment, per $1,000,000 spent. Income quintiles: I = poorest, II = poorer, III = middle, IV = richer, V = richest.

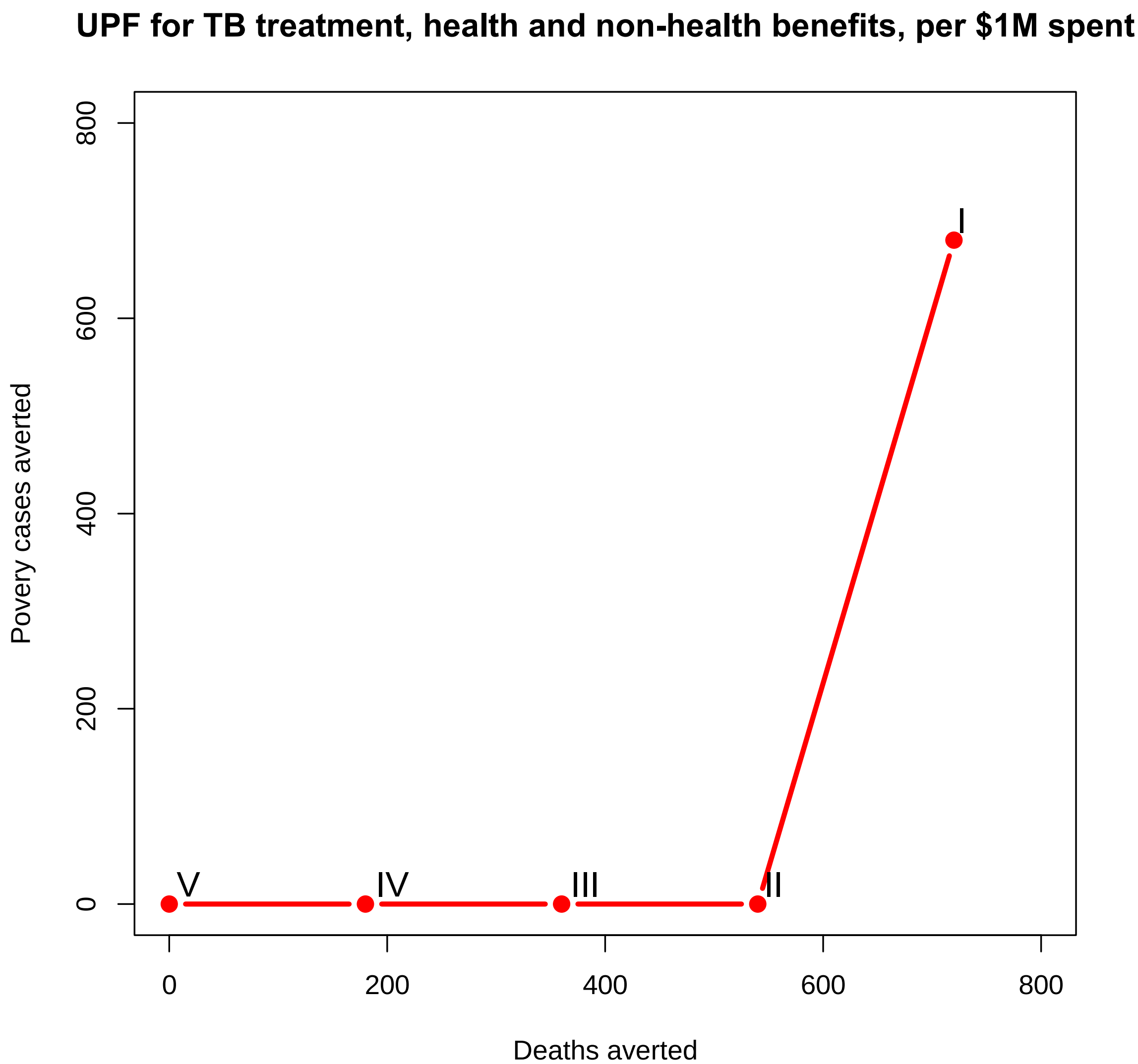


Figure 3. Illustration of the use of extended cost-effectiveness analysis (ECEA) in decision-making with the inclusion of one health domain (deaths averted by policy) and one non-health domain (financial risk protection (FRP) provided by policy), per dollar expenditure. As a simplification, the space of decision-making can be divided in four quadrants: high health benefits and high FRP; high health benefits and low FRP, low health benefits and high FRP, low health benefits and low FRP.