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Universal Public Finance of Tuberculosis Treatment in India:

An Extended Cost-Effectiveness Analysis

by

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Abstract

Universal public finance (UPF) for a health intervention entails consequences in multiple domains. First, UPF increases uptake of the intervention and hence the extent of consequent health gains. Second, UPF generates financial consequences including the crowding out of private expenditures. Finally UPF provides insurance either by covering catastrophic expenditures or by preventing diseases that necessitate them. This paper develops a method – extended cost-effectiveness analysis or ECEA – for evaluating the consequences of UPF in each of these domains. It then illustrates ECEA with an evaluation of UPF for tuberculosis treatment in India. Using plausible values for key parameters, our base case India ECEA concludes that health gains would be concentrated among the poor and that the insurance value of UPF would accrue primarily to middle income groups. A variant on our base case suggests that lowering costs of borrowing for the poor could potentially achieve many of the health gains of UPF, but at the cost of leaving the poor more deeply in debt.

1. Introduction

Using data from 40 low- and middle-income countries, Kruk *et al.* (2009) found that about 25% of households borrowed money or sold assets to pay for health care. In consequence, out-of-pocket (OOP) medical costs are a leading cause of impoverishment in many countries (for India, see Sengupta, 2005). Cross-country data confirm that high OOP health payments increase risk for high poverty rates (van Doorslaer *et al.*, 2006).

Because of the importance of health-related financial risks, international agencies and scholars have pointed to the importance of health sector policies to attenuate these risks. The World Bank (1993) in its World Development Report on *Investing in Health* argued for public finance of an "essential package" of public health and clinical services and addressed issues of risk pooling more generally.[3] The World Health Organization's 1999 World Health Report (WHR) (WHO, 1999) provided extensive discussion of risk pooling and advocated a "new universalism" involving universal public finance (UPF) for all individuals but not for all interventions. The 2000 WHR (WHO, 2000) included measures of financial protection as an element of health system performance and the entire subject of the influential WHR for 2010 (WHO, 2010a) was on "paths to universal coverage." These examples illustrate the political and economic salience of quantifying the insurance or financial protection consequences of health policies in general and of UPF in particular.[4]

[3] See also the book used in the World Bank's flagship course in health finance (Berman *et al*., 2004) and the Bank's health policy strategy (World Bank, 1997).
[4] Evaluations of Mexico's *Seguro Popular* (Knaul *et al*., 2006; King *et al*., 2009) and the US Medicare program (Finkelstein and McKnight, 2005; McClelland and Skinner, 2009)

Despite much attention to its significant potential as part of broader social insurance, UPF tends in practice to cover few interventions in most low- and middle-income countries, and there is little consensus on what interventions should be covered in highly resource-constrained environments. The question of what to cover using UPF – i.e. of the context of the basic benefits package – brings us to the fundamental intent of the programs, which goes beyond improving health and is tied to financial risk protection. For instance, the opening page of the United Kingdom's National Health Service document of July 5, 1948, reads "...there are no charges, except for a few special items. There are no insurance qualifications. But it is not a 'charity.' You are all paying for [the NHS], mainly as taxpayers, and it will relieve your money worries in times of illness." Financial risk protection goals are even more salient in developing countries where social insurance programs such as sick leave and unemployment and retirement coverage fail to cover significant segments of the population.

In this paper, we develop methods for incorporating measures of financial protection into the systematic economic evaluation of health policy. This enables construction of benefit packages based on quantitative inclusion of information of how much financial protection is being bought, as well as how much health is being bought with, say, a million dollar expenditure on an intervention or policy. We label our approach "extended cost-effectiveness analysis" or "ECEA," and illustrate its application with the example of UPF as an instrument for improving access to and performance of tuberculosis (TB) treatment in India.

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have shown both these programs to have quantifiable insurance value resulting from broad pooling of risks.

ECEAs of health policy instruments utilize standard cost-effectiveness (CEA) results on dollar costs per unit of health gain. But ECEA goes beyond CEA in three dimensions each of which is essential for evaluation of policy. First, some health policy instruments (and particularly UPF) will provide insurance against financial risks. Second, policies have direct financial implication both because of the revenue generation required to pay for them and because of private expenditures that may be crowded out. Finally, UPF and other health policy instruments have distributional consequences across wealth strata of a population. ECEAs assess consequences in these additional dimensions.

Our initial application of ECEA addresses UPF and we begin with motivations for that choice.[5] First, households' catastrophic health expenditures can often be substantial without prepayment mechanisms (Wagstaff and van Doorslaer, 2003; Xu *et al.*, 2003; van Doorslaer *et al.*, 2007; Chatterjee, 2010). Wagstaff (2010) provides a valuable overview of the methods and findings of the literature on catastrophic expenditure, and the World Health Organization provides an extensive and up to date review of the literature of UPF (WHO, 2010).[6] For example, in resource-poor settings, the treatment costs incurred due to TB, malaria, and AIDS are often considerable for households (Russell, 2004). In the United States, a large poor population bearing the burden of non-communicable diseases lacks financial protection (Waters *et al.*, 2004). Subject to the budget constraint, UPF provides insurance by pooling these risks (Gruber, 2007). Second,

[5] Jamison (2009) divides policy instruments into the following categories: mass education campaigns, legal and regulatory policies, financial policies (taxation, subsidies, user fees, and conditional cash transfers), engineering policies and direct government provision of services or training. While this paper focuses on the financial instrument of UPF, ECEAs can also assess other policy instruments.

[6] Recently, Smith (2012) offered a theoretical model in which risk-averse individuals valued financial protection from rare events. Smith's model tried to incorporate elements of policy into the usual practice of cost-effectiveness analysis.

UPF can enable access to care that would otherwise be unaffordable (Nyman, 1999), although again public sector budget constraints limit the extent of such access. Third, financial consequences of UPF include crowding out of private expenditures and the potential need for increased taxation. Fourth, UPF can become a mechanism to bring in quality by crowding out ineffective medicines used in lieu of more effective available interventions (WHO, 2010a). Finally, UPF can provide an equalizing influence across income groups for both health and financial outcomes. Given that mandatory contributions of the richest can fund the needs of the poorest UPF is potentially equality enhancing (WHO, 2010a). That said, this effect may be counterbalanced by crowding out of private expenditures among the better off.

Section 2 introduces our methods for undertaking ECEAs. Section 3 then applies ECEA to the example of UPF for TB treatment in India and Section 4 concludes. Our objective is to present and apply a working method that can be used for economic evaluation of the policy instruments which influence the uptake and quality of delivery of health interventions. Our application to India is calibrated from multiple data sources and provides important suggestive empirical results even though definitive treatment must await improved data.

2. Methods

We consider the implementation of UPF for the treatment of a disease in a population. We assess the level and distribution across wealth quintiles of the burden of disease averted (lives saved) (section 2.1); the private expenditures crowded out, taxes raised to sustain the program and hence the net effect on private expenditures (2.2); and, finally, the financial protection provided by UPF, measured in this paper by the money-metric value of insurance provided (2.3). (While money-metric value of insurance constitutes, in our view, the most appropriate concept of financial protection there are other (complementary) measures that could be used. These include asset sales averted, forced borrowing averted or impoverishments averted.)

This paper presents the results of ECEA in a 'dashboard' that conveys, separately for each income quintile, the health and financial protection consequences of the policy instrument relative to the status quo. It is clear that with appropriate aggregation assumptions all entries on the dashboard could be collapsed into a single figure of merit. Our judgement, in going no further than presenting the dashboard, was that the inevitably arbitrary assumptions underlying aggregation would obscure the conclusions of an ECEA.

In the population, we define: y, the annual income of an individual, y_l and y_h the lowest and highest incomes, respectively, and $f(y)$, the income distribution; c, the cost of the treatment for the disease, and s the cure rate corresponding to that treatment. We note b_c, the probability of privately purchasing the treatment for the disease at cost c, conditional on having the disease, before the introduction of UPF. We assume b_c to depend on income y, i.e. $b_c(y)$. We further assume the disease to have an annual incidence of probability p, and that p varies in a well defined way with income y, i.e. $p(y)$.[7] The untreated disease is lethal with a case fatality rate d_0. All the symbols used are listed and defined in Table 1.

Table 1. Symbols used in the model for universal public finance and corresponding definitions

Symbol	Definition
Y	Individual income
y_l, y_h	Lowest, highest income
$f(y)$	Income distribution as a function of individual income
C	Cost of the treatment
S	Cure rate for the treatment
$b_c(y)$	Probability of privately purchasing the treatment for th
$p(y)$	Disease incidence as a function of individual income
d_0	Case fatality rate from untreated disease
t	Flat tax rate
R	Coefficient of constant relative risk aversion
$w(y)$	Utility function as a function of individual income y

[7] An alternative to using annual income and annual disease incidence would be to use lifetime values for these parameters. For given disease treatment cost using lifetime values for these parameters would affect the value of financial protection in a predictable way (see equation 13). As a simplification, the effect of greater lifetime income in reducing the insurance value of UPF approximately counterbalances the effect of greater lifetime incidence probability in increasing the value of insurance. Using annual income and incidence numbers represents both a reasonable first approximation and an attempt to stay close to observable data.

2.1. Lives saved

Before the introduction of UPF, the probability of dying from the disease, conditional on having it, d_a, depends on the probability of privately purchasing treatment $b_c(y)$ and the treatment cure rate s. In other words:

$$d_a(y) = b_c(y)(1-s)d_0 + \big(1-b_c(y)\big)d_0$$

$$= d_0\big(1-sb_c(y)\big). \qquad (1)$$

After the introduction of UPF, every individual obtains treatment[8] and therefore the probability of dying from the disease, conditional on having it, d_p, is:

$$d_p = (1-s)d_0. \qquad (2)$$

The differential of deaths between ante- and post- UPF introduction follows:

$$\Delta d(y)p(y) = \big(d_a - d_p\big)p(y)$$

$$= d_0 s(1-b_c(y))p(y). \qquad (3)$$

The total number of lives saved (per capita), H_t, is given by:

$$H_t = \int_{y_l}^{y_h} \Delta d(y)p(y)f(y)dy$$

$$= \int_{y_l}^{y_h} d_0 s\big(1-b_c(y)\big)p(y)f(y)dy. \qquad (4)$$

(4) is a static formulation of the health gains brought by UPF. Evidently, in the case of infectious diseases such as TB, treatment can further prevent secondary cases and reduce

[8] The (unrealistic) assumption that UPF will lead to universal coverage can easily be generalized.

disease incidence, eventually bringing additional health benefits. A dynamic transmission model could capture such epidemiological consequences.

2.2. Consequences for private expenditures

We estimate the amount of private expenditures averted by the introduction of UPF. For one individual, the private expenditures averted, conditional on having the disease, are:

$$g(y) = cb_c(y), \tag{5}$$

where we recall c is the treatment cost. The total amount of private expenditures averted (per capita), G_t, is given by:

$$G_t = \int_{y_l}^{y_h} p(y)g(y)f(y)dy$$

$$= \int_{y_l}^{y_h} cp(y)b_c(y)f(y)dy. \tag{6}$$

From the public sector perspective, the total treatment costs incurred (per capita) T are:

$$T = \int_{y_l}^{y_h} cp(y)f(y)dy. \tag{7}$$

T can be financed with a tax, of constant rate t for example, with:

$$t = \frac{\int_{y_l}^{y_h} cp(y)f(y)dy}{\int_{y_l}^{y_h} yf(y)dy}, \tag{8}$$

where an individual of income y pays the taxes ty.

At the individual level, the net private expenditures averted by UPF, k, is the difference between the expected private expenditures averted by UPF and the taxes paid:

$$k(y) \ = \ cp(y)b_c(y) - ty. \tag{9}$$

The total amount of private expenditures averted by UPF (per capita), K_t, is:

$$K_t \ = \ \int_{y_l}^{y_h} [cp(y)b_c(y) - ty] f(y)dy. \tag{10}$$

2.3. Money-metric value of insurance

We apply a standard utility-based model where risk-averse individuals value protection from the risk of uncertain adverse events (Pratt, 1964; Arrow, 1965; Feldstein and Gruber, 1995). We estimate the expected value of the gamble associated with the eventuality of the disease with probability *p(y)* and treatment cost *c*. Our focus in this paper is on the cost of treatment and excludes the cost of earnings or productivity reduced by the disease. Other forms of social insurance (e.g. disability insurance, sick leave, and unemployment insurance) are intended to provide protection against these risks. That said, the model we develop could be expanded to include the risk of lost income.

We utilize a constant relative risk aversion (CRRA) utility function: $w(y) = \frac{y^{1-r}}{1-r}$, for $r > 0$ and $r \neq 1$ and where *y* is income and *r* is the Arrow-Pratt coefficient of relative risk aversion. (When $r = 1, w(y) = \ln(y)$.) Estimated values for *r* vary widely in the literature: 0.48 (Keane and Wolpin, 2001), 0.73 (Hurd, 1989), 0.96 (Rosenzweig and Wolpin, 1993), 1 (Laibson *et al.*, 1998; Mitchell *et al.*, 1999), 1.5 (Cagetti and de Nardi, 2006), 2 (Mitchell *et al.*, 1999; Davis *et al.*, 2006), 3 (Hubbard *et al.*, 1995; Scholz *et al.*, 2006; Engen *et al.*, 2000).[9] Following McClellan and Skinner (2006) we use a coefficient of relative risk aversion $r = 3$, which implies a high degree of risk aversion. We also pursued calculations for alternative values of *r*, which are presented in Appendix A.

The expected value to an individual of the gamble concerning cost of treating the disease without UPF is:

$$y_p = (1-p)y + p(y-c). \tag{11}$$

The certainty equivalent for the same individual, noted as $y*$ is given by:

$$\begin{aligned} y^* &= w^{-1}[(1-p)w(y) + pw(y-c)] \\ &= [(1-p)y^{1-r} + p(y-c)^{1-r}]^{\frac{1}{1-r}}. \end{aligned} \tag{12}$$

The money-metric value of insurance at the individual level, *v(p,y,c)*, is then:

$$\begin{aligned} v(p,y,c) &= y_p - y^* \\ &= (1-p)y + p(y-c) - [(1-p)y^{1-r} + p(y-c)^{1-r}]^{\frac{1}{1-r}}. \end{aligned} \tag{13}$$

Therefore, the total money-metric value of insurance (per capita), V_t, is given by:

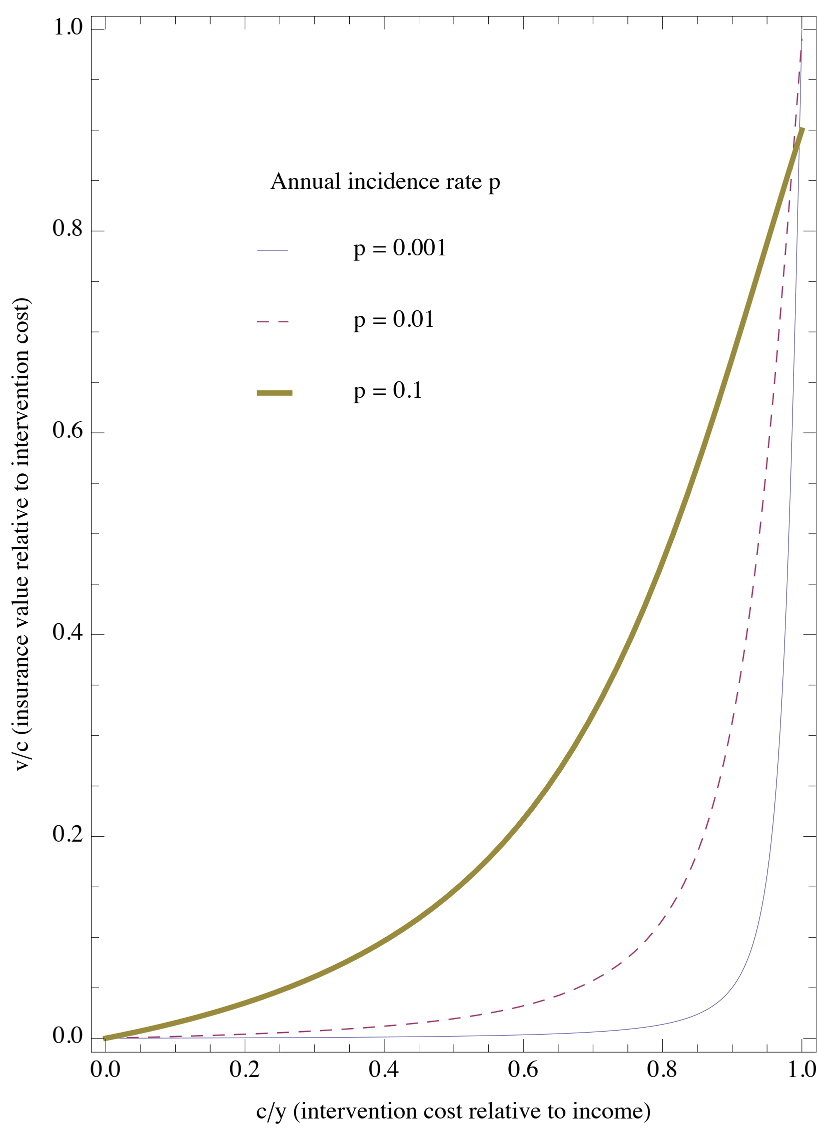
$$V_t = \int_{y_l}^{y_h} v(p,y,c) f(y) dy. \tag{14}$$

Equation (13) provides the key summarization of how the value of insurance (*v*) varies with the magnitude of risk (*p*), individual income y, the cost of treatment (*c*) and

[9] Some of these empirical estimates are for the intertemporal elasticity of substitution which, although formally identical to the coefficient of relative risk aversion, characterizes a conceptually distinct utility function.

curvature of the utility function (*r*). Figure 1 illustrates this relationship by normalizing *v* by *c* and *c* by *y*. Insurance value is thus expressed as a fraction of the cost of the intervention and intervention cost is expressed as a fraction of income. Note that increasing the value of *p* will (up to a point) increase *v/c*.

Figure 1. Individual money-metric value of insurance (relative to intervention cost) as a fraction of intervention cost (relative to income).



3. UPF of TB treatment in India

In India UPF has typically financed condition specific programs (e.g. against leprosy, AIDS and cataract blindness) or, more recently, secondary and tertiary care insurance such as the Rashtriya Swasthya Bima Yojana and the Arogyashree (in the state of Andhra Pradesh). The argument is made that these latter programs will provide more financial risk protection since they defray the high costs associated with hospitalizations. However, no quantitative assessment has been made of the amount of financial protection provided or whether more financial protection could be achieved with the same resources by, for example, financing prevention of cervical cancer (by HPV immunization) rather than by paying for its treatment. ECEA provides a systematic approach to answering these questions. We illustrate with the example of UPF for TB treatment.

TB treatment is well established as a medically cost-effective intervention (Dye and Floyd, 2006) and a typical cost-effectiveness finding would be that it costs less than $1,000 to avert a death from TB using modern drug treatments. Partly because of this low cost per death averted and partly because of the size of India's remaining TB burden, Jha and Laxminarayan (2009) include TB treatment in the "entitlement package" of interventions they recommend for India. An ECEA adds financial protection (and distributional) considerations to further inform discussion on entitlement packages.

Annually, there are about 2 million active infections and 330,000 deaths from TB in India (WHO, 2011). Private health expenditure constitutes a large majority of India's total health expenditure and most TB patients go to a private practitioner or private clinics for their first visit (Uplekar *et al.*, 2001; Uplekar *et al.*, 1996). Increasingly, however, government is assuming responsibility for financing TB treatment hence the importance of as a full economic evaluation of this investment. The ECEA in this section proceeds in three parts. The first part presents Indian data. The second part (3.2) presents results for a base case scenario using the methods described in Section 2. The third part (3.3) extends the base case scenario to three additional considerations: i) an alternative scenario for the private finance of treatment prior to UPF introduction, where ineffective and not necessarily cheap treatment is purchased by the poor; ii) higher costs of treatment in lower income quintiles and, (iii) borrowing and asset selling by the poor as ways of inter-temporally smoothing consumption in the face of treatment cost risks.

3.1. Data sources

We assume an average TB incidence of p_0 = 167 per 100,000 per year (World Health Organization, 2010b). The incidence is assumed exponentially distributed across income quintiles (with a ratio ρ between 1st and 9th income deciles y_1 and y_9): $p(y) = p_f e^{-y/\lambda}$, where, emprirically $\lambda = (y_9 - y_1)/1.4$ and $p_f = p_0(y_9 - y_1)/\int_{y_1}^{y_9} e^{-u/\lambda} du$ (Muniyandi *et al.,* 2007). The case fatality rate for untreated TB is d_0 = 0.25 (Bacaër *et al.*, 2008; Corbett *et al.*, 2003; Tiemersma *et al.*, 2011). The income distribution follows a truncated Gamma distribution based on a gross domestic product per capita of US$1,219 (International Monetary Fund, 2011) and a Gini coefficient of 0.36 (Central Intelligence Agency, 2011), and lowest and highest incomes of y_l = US$200 and y_h = US$20,000, respectively. The cost of Directly Observed Treatment Short Course (DOTS) is c_g =

US$83 and its cure rate is $s_g = 0.87$ (World Health Organization, 2010b).[10] Finally, we assume that, before the introduction of UPF, individuals with income y within the first three income deciles (30% of the total population; $y < y_3$ = US$735) do not privately purchase treatment when they are TB-infected; individuals beyond the first three income deciles privately purchase DOTS when they are TB-infected. All the parameters used are listed in Table 2.

[10] The $83 treatment cost assumes a case responsive to first line drugs. This situation is far less costly and time consuming than treating a drug-resistant case. If the overall program envisioned dealing with resistant cases, the average cost per case might be twice as high as assumed here.

Table 2. Parameters used in the model for universal public finance of tuberculosis treatment in India, and corresponding references

Input	Value	References
Tuberculosis incidence	$p_0 = 167\ per\ 100{,}000$ per year	WHO (2010b) Muniyandi *et al*. (2007) Authors' assumption
Untreated tuberculosis case fatality rate [a]	$d_0 = 0.25$ per active case	Bacaër *et al*. (2008)
DOTS cure rate	$s_g = 0.87$ per correctly treated case	WHO (2010b)
DOTS cost	$c_g =$ US$83 per course of treatment	WHO (2010b)
Income distribution	Gamma(2.2,556) GDP per capita = US$1,219 Gini coefficient = 0.36 Lowest income y_l = US$200 Highest income y_h = US$20,000	International Monetary Fund (2011) Central Intelligence Agency (2011) Authors' assumption
Loan interest rate	m = 0.20 per year	Authors' assumption
Personal discount rate	q = 0.03 per year	Authors' assumption

[a] Data on TB mortality without treatment goes back to the era when no effective treatment was available. For untreated HIV-negative individuals, Corbett *et al*. (2003) and Tiemersma *et al*. (2011) give case fatality rates of 0.70 and 0.20 for smear-positive and culture-positive smear-negative tuberculosis, respectively, with a duration of 2 to 3 years to self-cure or death. A case fatality rate of 0.25 per year is what Bacaër et al. (2008) used.
DOTS = Directly Observed Treatment Short Course.

3.2. Base case scenario

The results for the base case scenario are listed in Table 3, for a population of 1,000,000 in India.

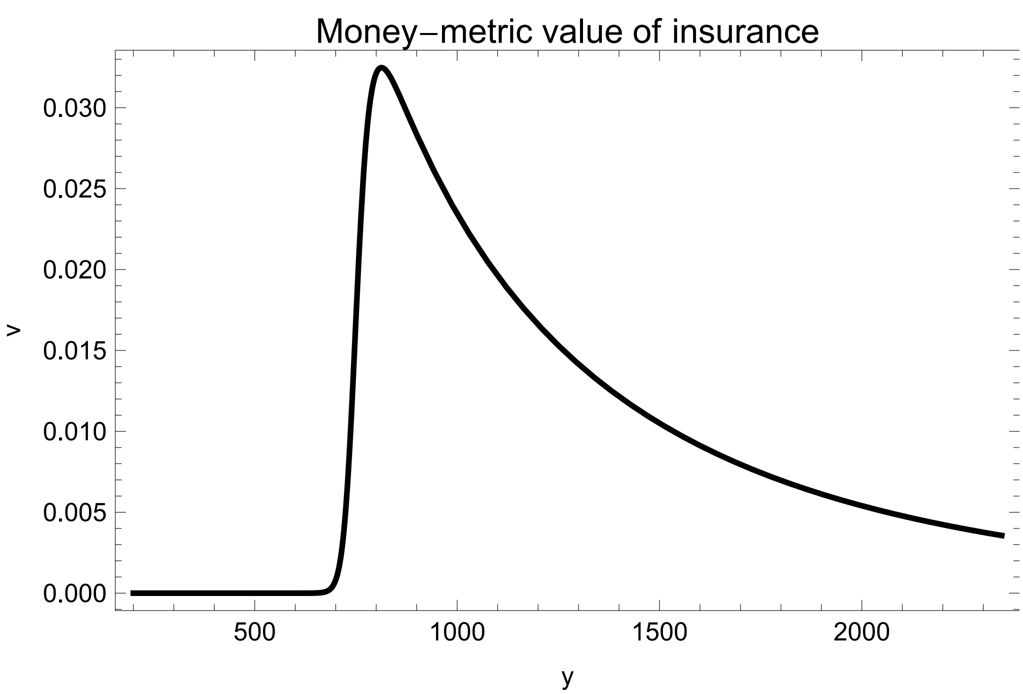
Table 3. Level and distribution of benefits over 1 year for an Indian population of 1,000,000 with the introduction of universal public finance of tuberculosis treatment

Outcome	Total	Income Quintile I	Income Quintile II	Income Quintile III	Income Quintile IV	Income Quintile V
TB deaths averted	190	130	60	0	0	0
Private expenditures crowded out	$86,000	0	19,000	32,000	23,000	12,000
Taxes	- $160,000	- 10,000	- 19,000	- 27,000	- 39,000	- 65,000
Net private expenditures averted[a]	- $73,000	- 10,000	500	5,000	- 16,000	- 52,000
Insurance value	$10,000	0	3,000	4,000	2,000	700

[a] The net private expenditures averted are the net sum of the private expenditures averted and the taxes.

The total number H_t of lives saved is about 190 per year. Table III exhibits the distribution of the lives saved across different income quintiles: the health benefits are concentrated among the poorest (71%) as they would not purchase treatment prior the introduction of UPF. The total number of private expenditures averted by UPF is G_t = US$86,000. For the lowest income quintile, the private expenditures averted are null, as the poorest would not purchase treatment prior the introduction of UPF. The second and third income quintiles benefit from about 59% of the private expenditures averted. The total treatment costs incurred by UPF are US$160,000, which can be raised with a constant tax rate on income of t = 0.013%. The two highest income quintiles contribute to 65% of the tax revenues. The total net private expenditures averted is K_t = - US$73,000. Only the second and third income quintiles see positive net private expenditures averted. The total insurance value V_t is US$10,000. For the lowest income quintile, the insurance value is null as the poorest would not purchase treatment prior the introduction of UPF; UPF brings substantial financial protection to the second and third income quintiles who collect about 73% of the total insurance value. Figure 2 shows how insurance value varies with income and illustrates that for high-income individuals self-insurance entails limited welfare losses.

Figure 2. Individual money-metric value of insurance



Note: The figure shows the per person annual insurance value of UPF for TB treatment in India.

3.3. Alternative scenarios

3.3.1. Alternative prior privately financed treatment

The poor would not purchase TB treatment at the public hospital level for various reasons including transportation cost, time cost, and opportunity cost. Most lower income people prefer to see a private physician after working hours than to take a day off work without pay to visit a doctor in a public hospital (Kumar and Kumar, 1997). Yet, the TB treatment purchased there can be ineffective: ignorance exists among private doctors about efficient treatment (Uplekar and Shepard, 1991) and financial incentives of the provider may conflict with patient care interests. In a study of 105 private practitioners, 79 different regimens were prescribed, different durations of treatment (6 to 18 months) were observed, and the average treatment adherence rate for patients was 55% (Uplekar *et al.*, 1996). A potential virtue of UPF is to crowd out low quality or inappropriate treatment in the private sector. We stress that this outcome depends of a well-managed public sector program, something widely achieved only in parts of India and for some centrally run categorical programs of which TB treatment is an example in a number of countries.

Assume that, before the introduction of UPF, a TB treatment of lower cost $c_b = c_g/2$ = US$43 and lower cure rate $s_b = s_g/4 = 0.22$ is available for private purchase to the lower income people; that higher income people still purchase DOTS; that people within the first three income deciles now purchase the lower quality treatment of effectiveness s_b and cost c_b. The results corresponding to this scenario are listed in Table 4, for a population of 1,000,000 in India. The total lives saved now amount to 143; the private expenditures averted become more substantial (US$120,000), and 45% of these are concentrated among the two lowest income quintiles; the bottom three income quintiles have now positive net private expenditures averted; the insurance value becomes larger (US$17,000) and largely concentrated (58%) among the poorest and the near poor. In summary, the distribution of private expenditures averted and insurance value has now shifted toward the poorest and the near poor. In this case, UPF can also be seen as a means to crowd out ineffective private treatment expenditures, enabling the uptake of a higher quality treatment and increasing technical efficiency.

Table 4. Level and distribution of benefits over 1 year for an Indian population of 1,000,000 with the introduction of universal public finance of tuberculosis treatment for alternative prior privately financed treatment.

Outcome	Total	Income Quintile I	Income Quintile II	Income Quintile III	Income Quintile IV	Income Quintile V
TB deaths averted	140	100	40	0	0	0
Private expenditures crowded out	$120,000	26,000	30,000	32,000	23,000	12,000
Taxes	- $160,000	- 10,000	- 19,000	- 27,000	- 39,000	- 65,000
Net private expenditures averted[a]	- $37,000	16,000	11,000	5,000	-16,000	- 52,000
Insurance value	$17,000	5,000	5,000	4,000	2,000	700

[a] The net private expenditures averted are the net sum of the private expenditures averted and the taxes.

3.3.2. Increasing costs toward achieving universal public finance

UPF promotes universal access. However it is plausible that the cost of provision of TB treatment rises as hard-to-reach populations become included, in contrast to our base case assumption. In this scenario, we assume that the unit cost of providing TB treatment to the lowest three income deciles is twice that of providing it to the other income strata. The total treatment costs for the public sector increase to US$230,000, which can be raised with a constant tax rate on income of about 0.019%. As a consequence in this scenario all income quintiles see negative net private expenditures averted (Table 5).

Table 5. Level and distribution of benefits over 1 year for an Indian population of 1,000,000 with the introduction of universal public finance of tuberculosis treatment with increasing costs toward achieving universal public finance.

Outcome	Total	Income Quintile I	Income Quintile II	Income Quintile III	Income Quintile IV	Income Quintile V
TB deaths averted	190	130	60	0	0	0
Private expenditures crowded out	$86,000	0	19,000	32,000	23,000	12,000
Taxes	- $233,000	- 15,000	- 27,000	- 40,000	- 56,000	- 94,000
Net private expenditures averted[a]	- $146,000	- 15,000	- 8,000	- 8,000	- 33,000	- 82,000
Insurance value	$10,000	0	3,000	4,000	2,000	700

[a] The net private expenditures averted are the net sum of the private expenditures averted and the taxes.

3.3.3. Borrowing and asset sales

When faced with costly medical treatment, the poor can use coping mechanisms such as borrowing from relatives and peers or selling assets (Kruk *et al.* 2009; Wagstaff, 2010; Banerjee and Duflo, 2007). For instance, more than 40% of all patients admitted to hospital in India have to borrow money or sell assets, including inherited property and farmland, to cover expenses (Sengupta, 2005). One approach to providing financial protection to populations is to provide mechanisms to reduce the cost of borrowing or to increase the return on asset sales. For example, financial protection could result from improving institutional arrangements to allow, without subsidy, an improved interest rate for borrowing by poor people. We discuss this below.

In an attempt to represent a potential access to capital markets into the analysis – rather than a base case of having no capital markets – improved institutional arrangements allow that the poorest to take a loan at an interest rate *m*, over a period of *n* years, as an alternative to UPF. For example, assume people in the three lowest income deciles take such a loan when they are confronted with TB treatment expenditures of c_g, in order to purchase DOTS. The annual payment for the loan, *a*, is:

$$a(m,n) = c_g \frac{m}{1-(1+m)^{-n}}, \qquad (15)$$

and the total debt for the borrower (present value) becomes:

$$L(m,n,q) = \sum_{k=1}^{n} \frac{a(m,n)}{(1+q)^k}$$

$$= c_g \frac{m}{1-(1+m)^{-n}} \left(\frac{1-(1+q)^{-n}}{q}\right) \qquad (16)$$

where q is the borrower's personal discount rate. This inclusion of improved capital markets in the model leads to a change in the private expenditures averted and the value of insurance in the two lowest income quintiles, as the poorest who are TB-infected now face private expenditures of a in that first year. Assume an annual interest rate $m = 0.20$, a TB treatment cost c_g = US$83, a loan period $n = 10$ years, and a personal discount rate $q = 0.03$. The results are collected in Table 6. In this example, there are no lives saved by UPF as the improved capital market now allows the poor to purchase DOTS prior to UPF introduction. The distribution of private expenditures averted and insurance value of UPF has, however, now shifted toward the poorest and the near poor. The annual loan payment is US$34 and the present value of total debt associated with borrowing is US$169 (Table 7). The values of annual payment, debt associated with borrowing, insurance value, private and net private expenditures averted increase as the interest rate increases (or the adequacy of capital market improvements) (Table 7).

Table 6. Level and distribution of benefits over 1 year for an Indian population of 1,000,000 with the introduction of universal public finance of tuberculosis treatment with access to capital markets.

Outcome	Total	Income Quintile I	Income Quintile II	Income Quintile III	Income Quintile IV	Income Quintile V
TB deaths averted	0	0	0	0	0	0
Private expenditures crowded out	$235,000	110,000	65,000	32,000	23,000	12,000
Taxes	- $160,000	- 10,000	- 19,000	- 27,000	- 39,000	- 65,000
Net private expenditures averted[a]	$75,000	100,000	76,000	5,000	- 16,000	- 52,000
Insurance value	300,000	260,000	30,000	4,000	2,000	700

[a] The net private expenditures averted are the net sum of the private expenditures averted and the taxes.

Table 7. Financial outcomes to the bottom income quintile associated with replacing borrowing at indicated interest by insurance (UPF)

Interest rate (% per year)	Individual annual payment[a]	Individual debt[a]	Insurance value	Private expenditures crowded out	Taxes	Net private expenditures averted[b]
0	8.3	71	18,000	44,000	-10,000	34,000
5	11	92	34,000	57,000	-10,000	47,000
10	14	115	64,000	72,000	-10,000	62,000
15	17	141	122,000	88,000	-10,000	78,000
20	20	169	262,000	105,000	-10,000	95,000

Individual annual loan payment and debt associated with borrowing (present value); money-metric insurance value, private and private expenditures averted for the bottom income quintile of an Indian population of 1,000,000 over 1 year, varying with the interest rate in the capital markets

[a] The annual payment and debt associated with borrowing are estimated for one individual within the bottom income quintile. [b] Defined as difference between two previous columns.

In the inclusion of capital markets, an alternative time perspective is to consider the time span of the individual's lifetime or of the loan period (here *n* years). We have pursued such an alternative analysis, which is presented in Appendix B. The values of annual payment and debt associated with borrowing stay unchanged; and the insurance value, private and net private expenditures averted for the lowest income quintile still decrease as interest rate decreases (or the availability of capital markets increases) (Table B.2). As a whole, the private and insurance value becomes substantially concentrated among the poorest: 45% and 90%, respectively (Table B.1).

This example illustrates that improved capital markets for the poor can serve as an effective substitute for insurance (UPF) in averting TB deaths. Improving capital markets has the advantage of lower costs to the public sector and improvements in the net income position of the top two income quintiles. It has the disadvantage of burdening the poor with heavy debt.

Our economic evaluation of UPF for TB treatment in India presents limitations. A more detailed assessment would provide more realistic assumptions regarding disease modeling and drug resistance benefits, more comprehensive estimates of costs for TB treatment (e.g. households' transportation costs and time costs), improved estimates of the price and income elasticity of demand for treatment of different types, and deadweight loss due to taxation. There is also the lack of a detailed description and corresponding pricing of the existing underlying mix of public vs. private purchase of TB treatment. Indeed, Indians are overwhelmingly using the private health sector (although with important regional variation), which accounts for 82% of outpatient visits and 58% of inpatient expenditure (Sengupta, 2005). In addition, private TB treatment is also substantially more expensive: private practitioners advise more tests and supplement drug prescriptions with additional medicines (Uplekar *et al.*, 1996). Standard recommended regimens cost on average 5 times less than regimens prescribed by private doctors (Uplekar and Shepard, 1991). Future work will also examine the policies to be developed to administer prepayment mechanisms, precisely who should financially contribute and in which way. Important considerations include: government revenues to create pooled funds, refunds to cover transport costs, microcredit schemes, etc. given that the poorest cannot financially contribute via income taxes; mandatory contributions of the richest to avoid insufficient funding for the needs of the poorest (WHO, 2010a).

4. Discussion

We presented in this paper methods for the economic evaluation of UPF and other health policy instruments, which we label "extended cost-effectiveness analysis" or "ECEA." ECEAs go beyond CEA in assessing consequences in three additional dimensions: protection against financial risks; direct financial implications; and distributional consequences across wealth strata of a population. We illustrate ECEA by applying it to evaluation of UPF of tuberculosis treatment in India.

Under hypothetical but plausible assumptions, our ECEA example concluded that replacement of private finance for TB treatment in India with UPF could lead to substantial health gains concentrated among the poor. In particular ECEA allows quantification of the value of UPF in terms of access gains i.e. how insurance enables access to care that would otherwise be unaffordable (Nyman, 1999). The results are sensitive to key assumptions but using the (plausible) assumptions from India of our example UPF could substantially reduce TB deaths among the poor and near poor.

This India ECEA also illustrated the feasibility of quantifying the financial protection consequences of public finance of a specific intervention thereby facilitating informed consideration of financial protection outcome in the design of an essential package of publicly financed health services.

We extended our base case analysis to illustrate how UPF can be used as a mechanism to bring in quality and technical efficiency by crowding out the purchase of lower quality treatments.[11] Expensive and ineffective medicines are often used in lieu of cheaper and more effective available interventions. For example, in many low- and middle-income settings, ineffective drugs are overused at very high out-of-pocket prices. Crowding out unnecessary medicine expenditure can both save substantial funds and improve quality control (WHO, 2010a).

A final scenario assessed introduction of improved access to capital markets for the poor at relatively low (but non-subsidized) interest rates. Our analysis suggests that improving the capacity of the poor to go into debt for high payoff medical care (such as proper TB treatment) is a good substitute for UPF in saving lives of the poor. It would come at the cost, however, of increasing their debt burden. We emphasize in this context the need for better empirical evidence on measures of borrowing capacity, especially as how it varies with income levels (Banerjee and Duflo, 2007; Kruk *et al.*, 2009).

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[11] Julie McLaughlin of the World Bank pointed us to the potential importance of this mechanism.

This analysis focused on specific consequences of UPF including distributional consequences, and the money-metric value of insurance provided. Other potentially important benefits not incorporated here include the reduction of adverse selection (in environments where voluntary health insurance is otherwise an option) and in the social safety value of protection against lost labor. Our illustrative example is evidently tailored to a specific context and health intervention. Nonetheless, the framework introduced can be can be applied to the economic evaluation of other health interventions and health policy instruments such as conditional cash transfers or financial incentives (for example Fernald *et al.*, 2008; Banerjee *et al.,* 2010; Lim *et al.,* 2010; Thornton *et al.,* 2008). Perhaps most importantly it could be applied to evaluate the main policy alternative to UPF which is pro-poor public finance.

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APPENDIX A: ALTERNATIVE VALUES FOR THE COEFFICIENT OF RELATIVE RISK AVERSION

We performed a sensitivity analysis with alternative values for the coefficient of relative risk aversion *r* as defined in section 2.5 of the main text. We report in Table A.1 on the variations of the ensuing money-metric values of insurance.

Expectedly, the money-metric values of insurance increase as the coefficient of relative risk aversion *r* increases. However, the distribution (across income quintiles) remains unchanged.

Table A.1. Level and distribution of the money-metric value of insurance over 1 year for an Indian population of 1,000,000 for different values of the coefficient of relative risk aversion

Coefficient of relative risk aversion *r*	Total	Income Quintile I	Income Quintile II	Income Quintile III	Income Quintile IV	Income Quintile V
1/2	$1,600	0	500	700	300	100
1	$3,300	0	1,000	1,300	700	200
3	$10,000	0	3,400	4,200	2,100	700
5	$18,000	0	6,000	7,000	4,000	1,000

APPENDIX B. ALTERNATIVE *n*-YEAR TIME PERSPECTIVE

The time horizon considered is now n years. Over this time period, for one individual of income y, TB incidence becomes $\Pi = 1 - (1 - p(y))^n$, and the n-year-long individual income is $y\frac{1-(1+q)^{-n}}{q}$ where q is the discount rate. Prior to UPF, conditional on having TB, when $y < y_3$ (y_3 = US\$735), the individual faces private expenditures of $L(m, n, q) = c_g \frac{m}{1-(1+m)^{-n}}(\frac{1-(1+q)^{-n}}{q})$ (present value); when $y > y_3$, the individual faces private expenditures of c_g (undiscounted). The total costs (present value) of UPF are now $T = c_g \frac{1-(1+q)^{-n}}{q} \int_{y_l}^{y_h} \Pi(\mathrm{y}) f(y)dy$, which can be raised by a flat tax rate t on annual income. Therefore, the net private expenditures averted by UPF are given by $\Pi(\mathrm{y})c_g \frac{m}{1-(1+m)^{-n}}\left(\frac{1-(1+q)^{-n}}{q}\right) - ty\frac{1-(1+q)^{-n}}{q}$ when $y < y_3$ and $\Pi(\mathrm{y})c_g - ty\frac{1-(1+q)^{-n}}{q}$ when $y > y_3$. In any case, whether borrowing or not, the individual purchases DOTS, therefore in this simple case the number of lives saved by UPF is virtually null.

The money-metric value of the insurance at the individual level is:

$v = y\frac{1-(1+q)^{-n}}{q} + \Pi\left(y\frac{1-(1+q)^{-n}}{q} - c\right) - [(1-\Pi)(y\frac{1-(1+q)^{-n}}{q})^{1-r} + \Pi(y\frac{1-(1+q)^{-n}}{q} - c)^{1-r}]^{\frac{1}{1-r}}$, where $c = c_g \frac{m}{1-(1+m)^{-n}}\left(\frac{1-(1+q)^{-n}}{q}\right)$ when $y < y_3$ and $c = c_g$ otherwise. Assuming n = 10 years, m = 0.40, and q = 0.03, the results are collected in Table B.1. The total costs of UPF over 10 years will be of US\$1,600,000 (undiscounted), which can be raised at a flat tax rate of 0.013%. The lowest income quintile will need to pay taxes of US\$88,000 (present value).

In Table B.2 we also provide the evolution of the insurance value, private expenditures averted and net private expenditures averted for the lowest income quintile as a function of the interest rate *m*.

Table B.1. Level and distribution of benefits (present value) over 10 years for an Indian population of 1,000,000 with the introduction of universal public finance of tuberculosis treatment, with access to capital markets

Outcome	Total	Income Quintile I	Income Quintile II	Income Quintile III	Income Quintile IV	Income Quintile V
TB deaths averted	0	0	0	0	0	0
Private expenditures crowded out	$2,330,000	1,040,000	620,000	320,000	230,000	120,000
Taxes	- $1,400,000	- 90,000	- 160,000	- 230,000	- 330,000	- 550,000
Net private expenditures averted[a]	$1,040,000	940,000	560,000	90,000	- 100,000	- 430,000
Insurance value	$16,000	15,000	700	<100	0	0

[a] The net private expenditures averted are the net sum of the private expenditures averted and the taxes.

Table B.2. Financial outcomes to the bottom income quintile associated with replacing borrowing by UPF, in a lifetime income perspective

Interest rate (% per year)	Individual annual payment[a]	Individual debt[a]	Insurance value	Private expenditures averted	Taxes	Net private expenditures averted[b]
0	8.3	71	3,000	430,000	-90,000	340,000
5	11	92	4,000	560,000	-90,000	470,000
10	14	115	7,000	710,000	-90,000	620,000
15	17	141	10,000	870,000	-90,000	780,000
20	20	169	15,000	1,040,000	-90,000	700,000

Individual annual loan payment and debt associated with borrowing (present value); money-metric insurance value, private and private expenditures averted for the bottom income quintile of an Indian population of 1,000,000 over 1 year, with a lifetime income perspective, varying with the interest rate in the capital markets.

[a] The annual payment and debt associated with borrowing are estimated for one individual within the bottom income quintile. [b] Defined as difference between two previous columns.