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UNIVERSAL PUBLIC FINANCE OF TUBERCULOSIS TREATMENT IN INDIA: AN EXTENDED COST-EFFECTIVENESS ANALYSIS

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ABSTRACT

Universal public finance (UPF)—government financing of an intervention irrespective of who is receiving it—for a health intervention entails consequences in multiple domains. First, UPF increases intervention uptake 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, which would otherwise throw households into poverty or by preventing diseases that cause them. This paper develops a method—extended cost-effectiveness analysis (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 ECEA concludes that the health gains and insurance value of UPF would accrue primarily to the poor. Reductions in out-of-pocket expenditures are more uniformly distributed across income quintiles. A variant on our base case suggests that lowering costs of borrowing for the poor could potentially achieve some of the health gains of UPF, but at the cost of leaving the poor more deeply in debt. © 2014 The Authors. *Health Economics* published by John Wiley Ltd.

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1. INTRODUCTION

Out-of-pocket (OOP) medical costs are the leading cause of impoverishment in many countries,[1] and cross-country data confirm that high OOP health payments increase the risk for high poverty rates (van Doorslaer *et al*., 2006). Kruk *et al*. (2009) found that about 25% of households surveyed in 40 low-income and middle-income countries borrowed money or sold assets to pay for health care. When these medical costs are added to the income loss from major illness, Gertler and Gruber (2002) conclude that 'one of the most sizable and least predictable shocks to economic opportunities in developing countries is major illness.'

Because of their importance, international agencies and scholars have pointed to health sector policies to attenuate health-related financial risks. The World Bank (1993) in its World Development Report on *Investing in Health* argued for the public finance of an 'essential package' of public health and clinical services and

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[1]For India, see Sengupta and Nundy (2005).

addressed issues of risk pooling more generally.[2] The World Health Organization's (WHO) 1999 World Health Report (WHR) (WHO, 1999) provided extensive discussion of risk pooling and advocated a 'new universalism' involving universal public finance (UPF)—government financing of an intervention irrespective of who is receiving it—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 focus of the influential 2010 WHR (WHO, 2010) was on 'paths to universal coverage'. Furthermore, evaluations of Mexico's *Seguro Popular* (Knaul *et al*., 2006; King *et al*., 2009) and of the US Medicare program (McClellan and Skinner, 2006; Finkelstein and McKnight, 2008) have shown these programs to have quantifiable insurance value resulting from broad pooling of risks. That said, the absence of a cap on OOP spending has limited the insurance value of Medicare (Baicker and Levy, 2012).

Despite much attention to its significant potential as part of broader social insurance, UPF tends in practice to cover few interventions in most low-income and middle-income countries, and there is little consensus on what should be covered in highly resource-constrained environments. Low-income and middle-income countries usually do not offer comprehensive coverage; rather, they rely on personal finance of health care, through user fees, for example (Gertler and van der Gaag, 1990). The question of what to cover using UPF—i.e. of the contents 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.[3] In this paper, we develop methods for incorporating measures of financial protection into the systematic economic evaluation of health policy. This enables the construction of benefit packages based on the quantitative inclusion of how much financial protection is being bought, as well as how much health is being bought with a given investment on an intervention or policy.

We label our approach 'extended cost-effectiveness analysis' or 'ECEA'. ECEAs of health policy instruments utilize standard cost-effectiveness analysis (CEA) results on costs per unit of health gain. But ECEA builds on CEA in three dimensions, each of which enhances the ability of stakeholders to evaluate policy. First, some health policy instruments (and particularly UPF) will provide insurance against financial risks. Second, policies have direct financial implications because of the private expenditures that may be crowded out. Finally, health policy instruments have distributional consequences across wealth strata of a population.[4] ECEAs assess consequences in these three dimensions, and in this respect, they build on the existing frameworks of cost-benefit analysis and cost-consequence analysis tabulating disaggregated results (Mauskopf *et al*., 1998), and on analytical frameworks incorporating equity concerns into economic evaluations (Sassi *et al*., 2001; Cookson *et al*., 2009; Griffin *et al*., 2012; Culyer and Bombard, 2012; Fleurbaey *et al*., 2012; Norheim, 2013). ECEAs also build on a utility approach quantifying the welfare gains associated with reductions in risk exposure (McClellan and Skinner, 2006; Finkelstein and McKnight, 2008; Brown and Finkelstein, 2008). This utility approach was recently applied with the use of a theoretical model in which risk-averse individuals value financial protection from rare events, governments define a statutory package, and individuals choose additional voluntary insurance (Smith, 2007; Smith, 2013).

Our initial application of ECEA addresses UPF, and we begin with motivations for that choice. First, households' health expenditures can often be substantial without prepayment mechanisms (Wagstaff and van

[2]See also the book used in the World Bank's flagship course in health finance (Roberts *et al*., 2004) and the World Bank's health policy strategy (World Bank, 1997).

[3]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 National Health Service), mainly as taxpayers, and it will relieve your money worries in times of illness…' Financial 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.

[4]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. Although this paper focuses on the financial instrument of UPF, ECEAs can also assess other policy instruments.

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Doorslaer, 2003; Xu *et al*., 2003; van Doorslaer *et al*., 2007; Kruk *et al*., 2009; Chatterjee, 2010). Wagstaff (2010) provides a valuable overview of the methods and findings of the literature on catastrophic expenditures—defined as exceeding a certain fraction of total household expenditures—and the WHO provides an extensive review of the literature on healthcare financing including UPF (WHO, 2010). Second, UPF can enable access to care that would otherwise be unaffordable (Nyman, 1999), although again budget constraints limit the extent of such access. Third, financial consequences of UPF include crowding out of private expenditures. Fourth, UPF can become a mechanism to increase quality by crowding out ineffective medicines used in lieu of more effective interventions (WHO, 2010). Finally, UPF can influence equalization across income groups for both health and financial outcomes (WHO, 2010). That said, this effect may be counterbalanced by crowding out of private expenditures among the better off.

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 great financial protection because 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 rather than by paying for its treatment.

Annually, there are about two million active infections and 300,000 deaths from tuberculosis (TB) in India (Table I). Private health expenditures constitute a large majority of India's total health expenditures, and most TB patients go to private practitioners for their first visit (Uplekar *et al*., 2001; Uplekar *et al*., 1996; Satyanaryana *et al*., 2011). Increasingly, however, the government is assuming the responsibility for financing TB treatment (directly observed treatment, short-course [DOTS]). TB treatment is well established as a medically cost-effective intervention (Dye and Floyd, 2006). Partly because of this cost-effectiveness 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.

In this paper, we first introduce methods for undertaking ECEAs for UPF (Section 2). Section 3 then applies these methods to the example of TB treatment in India; Section 4 concludes. Our objective is to present and

Table I. Tuberculosis in India in 2011

Incident tuberculosis case type (treatment category)	Number of incident cases	Case fatality rate (% of cases)	Deaths	Cost per course of treatment (2011 US$)
1. Sputum smear-positive (ss+)				
1.1. ss+ (treated with DOTS[a])	700,000[b]	4[b]	30,000	$100[b,c]
1.2. ss+ (non-DOTS treatment)	125,000[d]	32[b]	40,000	50[e]
1.3. ss+ (untreated)	155,000[b,f]	32[b]	50,000	N/A
1. (Subtotal)	980,000	N/A	120,000	N/A
2. Sputum smear-negative (notified)	340,000[b]	7[b]	25,000	N/A
3. Extrapulmonary notified	225,000[b]	7[b]	15,000	N/A
4. Other notified	250,000[b]	7[b]	20,000	N/A
5. Other non-notified	405,000	32[b]	130,000	N/A
Total	2,200,000	N/A	310,000	N/A

This table uses data from multiple sources on incidence, fatality, and cure rates of tuberculosis of different types to create a consistent but only approximate summary of tuberculosis in India in 2011. The sources used rely, of necessity, on incomplete, and sometimes conflicting data. Hence, we stress the approximate character of the summary presented.

[a]DOTS (directly observed treatment, short-course) is the World Health Organization and Indian government recommended treatment modality.

[b]WHO (2012). 'Notified' means newly diagnosed case reported to the national tuberculosis control program.

[c]WHO (2011).

[d]Authors' assumption based on NSSO (2004) and WHO (2012).

[e]Authors' assumption based on Rajeswari *et al*. (1999).

[f]WHO (2009).

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apply a working method that can be used for economic evaluation of the policy instruments that influence the uptake and quality of delivery of health interventions.[5]

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 and the costs to sustain the program (Section 2.2); and, finally, the financial protection provided by UPF, by the money-metric value of insurance afforded (Section 2.3).[6]

In the population, we define the following: y, the annual income of an individual; y_l and y_h, the lowest and highest incomes, respectively; $f(y)$, the income distribution; c, the cost of the treatment for the disease; and s, the cure rate corresponding to that treatment. We note u and b_c, the treatment coverage and 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 u and b_c to depend on income y, that is, $u(y)$ and $b_c(y)$. We further assume the disease to have an annual incidence of probability p, and that p varies with income y, that is, $p(y)$.[7] The untreated disease is lethal with a case fatality rate d_0.

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 obtaining treatment $u(y)$ (pre-existing treatment coverage) and the treatment cure rate s. In other words

$$d_a(y) = u(y)(1-s)d_0 + (1-u(y))d_0. \tag{1}$$

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 $d_p = (1-s)d_0$. The differential of deaths between ante-UPF and post-UPF introduction follows as $(d_a - d_p)p(y)$. The aggregate number of lives saved (per capita), H, is given by

$$H = \int_{y_l}^{y_h} (d_a - d_p) p(y) f(y) dy \tag{2}$$

Additional forms of health measures (e.g. morbidity and disability-adjusted-life-years), which sometimes can be substantial, are not included for simplicity. That said, the model we develop could be easily adjusted to include these measures. In addition, (2) is a static formulation of the health gains brought by UPF. In the case of infectious diseases such as TB, treatment can prevent secondary cases. A dynamic transmission model could capture such epidemiological consequences, and, in a variant of our base case model (Section 3.2.2), we utilize first order estimates of the size of the effect.

[5]The BRAC (formerly Bangladesh Rural Advancement Committee) non-governmental organization in Bangladesh has implemented a variant of UPF for TB treatment there that is explicitly designed to improve cure rates. Individuals about to receive treatment post a modest 'bond' with the provider. The provider returns this bond when the patient successfully completes treatment creating strong incentives for adherence to the lengthy course of TB treatment. (BRAC exempts the very poor from the need to post a bond). See Islam *et al*. (2011).

[6]Although 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.

[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 (equation 8). 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.

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

DOI: 10.1002/hec

2.2. Consequences for private expenditures

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

$$e(y) = cu(y)b_c(y), \tag{3}$$

where we recall $b_c(y)$ is the probability of privately purchasing the treatment and c is the treatment cost. The aggregate amount of private expenditures averted, E, is given by

$$E = \int_{y_l}^{y_h} p(y)e(y)f(y)dy. \tag{4}$$

From the public sector perspective, the aggregate treatment costs incurred, TC, are

$$TC = \int_{y_l}^{y_h} cp(y)f(y)dy. \tag{5}$$

TC could be financed with a tax, of constant rate t, for example. We explore this financing mechanism in Appendix A in supporting information.

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; McClellan and Skinner, 2006; Brown and Finkelstein, 2008; Finkelstein and McKnight, 2008). We estimate the expected value of the gamble associated with the eventuality of the disease treatment with probability P and cost c. Our focus in this paper is on the OOP 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 extended to include the risk of lost income.

We utilize a constant relative risk aversion 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 $r \to 1$, $w(y) \to \ln(y)$.) In the uncertain scenario, the expected value of income to an individual of the gamble concerning cost of treating the disease without UPF is

$$y_p = (1 - P)y + P(y - c), \tag{6}$$

where $P(y) = p(y)u(y)b_c(y)$. In the certain scenario, the 'certainty equivalent' for the same individual, that is, the income she is willing to have in order to have the outcome certain, denoted as y^* is given by

$$\begin{aligned} y^* &= w^{-1}[(1 - P)w(y) + Pw(y - c)] \\ &= \left[(1 - P)y^{1-r} + P(y - c)^{1-r}\right]\frac{1}{1 - r}. \end{aligned} \tag{7}$$

The money-metric value of insurance (risk premium) at the individual level $v(P,y,c)$ is then

$$\begin{aligned} v(P, y, c) &= y_p - y^* \\ &= (1 - P)y + P(y - c) - \left[(1 - P)y^{1-r} + (y - c)^{1-r}\right]\frac{1}{1 - r}. \end{aligned} \tag{8}$$

Therefore, the aggregate money-metric value of insurance, V, is given by

$$V = \int_{y_l}^{y_h} v(P, y, c)f(y)dy. \tag{9}$$

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Table II. Parameters used in the model for universal public finance, corresponding definitions and references

Parameter definition	Symbol	Value	Source(s)
Individual income	y	• Gross domestic product per capita in 2011; mean value is \$1489	World Bank (2012)
Disease incidence (ss+ tuberculosis) as a function of individual income	$p(y)$	• Average of 100 per 100,000 • Four times more incident among the poorest than the richest	Based on WHO (2012) and Muniyandi *et al.* (2007)
Cost of the treatment	c	• \$100 for DOTS[a] treatment • \$50 for non-DOTS[a] treatment	Based on WHO (2012) and Rajeswari *et al.* (1999)
Treatment coverage assumptions	$u(y)$	• DOTS[a] coverage among quintiles before UPF: (0.47, 0.59, 0.71, 0.83, and 0.95); average of 0.71 • DOTS[a] coverage among quintiles after UPF: (0.85, 0.90, 0.90, 0.90, and 0.95); average of 0.90 • Non-DOTS coverage among quintiles before UPF: (0.24, 0.19, 0.11, 0.07, and 0.04); average of 0.13 • Non-DOTS coverage among quintiles after UPF: (0.08, 0.05, 0.05, 0.05, and 0.04); average of 0.05	Calibrated on WHO (2012); Satyanarayana *et al.* (2011); NSSO (2004)
Probability of privately purchasing the treatment	$b_c(y)$	• DOTS[a] treatment: 50% purchased privately; 50% free • Non-DOTS[a] treatment: 100% purchased privately	Niruparani *et al.* (2010)
Lowest income, highest income	y_l, y_h	\$200, \$20,000	Authors' assumption
Income distribution as a function of individual income	$f(y)$	Gamma (2.7, 563) (implies Gini coefficient of 0.33)	Estimated from India GDP per capita and Gini coefficient and based on Salem and Mount (1974)
Coefficient of relative risk aversion	r	3[b]	McClellan and Skinner (2006); Finkelstein and McKnight (2008)
Utility function as a function of individual income y	$w(y)$	$\frac{y^{1-r}}{1-r}$	Authors' assumption (but common in the literature)
Loan interest rate	m	0.20 constant, per year	Authors' assumption (see text)
Personal discount rate	q	0.03 constant, per year	Authors' assumption (see text)

ss+, sputum smear-positive; WHO, World Health Organization; DOTS, directly observed treatment, short-course; GDP, gross domestic product.
[a]DOTS (directly observed treatment, short-course) is the World Health Organization and Indian government recommended treatment modality.
[b]We explore the sensitivity of our results varying the value of this parameter in supporting information Appendix B.

2.4. Data inputs for universal public finance of tuberculosis treatment in India

All the parameters and sources are listed in Tables I and II. We assume an average incidence of $p_0 = 100$ per 100,000 per year (for sputum smear-positive [ss+] TB cases[9]). The incidence is assumed exponentially distributed across income quintiles (with a 4:1 ratio between bottom and top quintiles[10]). The cost of DOTS is \$100.[11] Before the introduction of UPF, about 71% of cases obtain DOTS treatment, a coverage which varies by income group; and about half of these 71% obtain DOTS treatment for free. Indeed, people would not necessarily purchase TB treatment at the public hospital level for various reasons including transportation cost and opportunity cost. Most lower income people prefer to see a private physician after working hours than to take

[9]By virtue of recommending smear microscopy, DOTS focuses on the detection of ss+ TB cases. Most low-income and middle-income countries have no access to culture. Therefore, only ss+ cases and a small subset of sputum smear-negative cases will be diagnosed with TB and started on treatment. Thus, our analysis focuses on ss+ TB cases only. In what follows, a 'TB case' will therefore refer to a 'ss+ TB case.'
[10]$p(y) = p_f e^{-y/\lambda}$, where, empirically $\lambda = (y_9 - y_1)/1.4$ and $p_f = p_0(y_9 - y_1)/\int_{y_1}^{y_9} e^{-u/\lambda} du$; y_1 and y_9 are the 1st and 9th income deciles, respectively.
[11]The \$100 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 (about 2% of all cases and 15% of retreated cases in India). If the overall program envisioned dealing with resistant cases, the average cost per case might be 10 times as high as assumed here (WHO, 2012).

DOI: 10.1002/hec

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; Udwadia *et al*., 2010) and financial incentives of the provider may conflict with patient care interests. A potential virtue of UPF is to crowd out low quality treatment in the private sector, enabling the uptake of a higher quality treatment and increasing technical efficiency. We stress that this outcome depends on 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. Hence, in our base case scenario, we assume that before UPF, 13% of cases obtain non-DOTS treatment (a coverage that also varies by income group); non-DOTS treatment is assumed to cost $50 and to be ineffective. Finally, UPF increases DOTS treatment coverage to 90% of cases (Table II).

The income distribution follows a truncated Gamma distribution based on a gross domestic product per capita of $1489 and a Gini coefficient of 0.33 and lowest and highest incomes of $200 and $20,000, respectively. Following a long line of literature (Mitchell *et al*., 1999; Hubbard *et al*., 1995; Scholz *et al*., 2006; Engen *et al*., 1999; McClellan and Skinner, 2006; Finkelstein and McKnight, 2008; Brown and Finkelstein, 2008), we use a coefficient of relative risk aversion $r=3$, which implies a high degree of risk aversion. However, in recognition of diverging opinions in the literature over the value of r (with for example the use of lower estimates of 0.48 by Keane and Wolpin (2001), 0.73 by Hurd (1989), 0.96 by Rosenzweig and Wolpin (1993), 1 by Laibson *et al*. (1998), 1.5 by Cagetti and de Nardi (2006), 2 by Davis *et al*. (2006)),[12] we also pursued calculations for alternative values of r (Appendix B in supporting information).

3. RESULTS

Equation (8) provides the key summarization of how the value of insurance (v) varies with the magnitude of risk (P), individual income (y), intervention cost (c), and curvature of the utility function (r). Figure 1 illustrates this relationship by normalizing v by c:

$$\begin{aligned}\overline{v} &= \frac{v}{c} \\ &= (1-P)\frac{y}{c} + P\left(\frac{y}{c}-1\right) - \left[(1-P)\left(\frac{y}{c}\right)^{1-r} + P\left(\frac{y}{c}-1\right)^{1-r}\right]^{\frac{1}{1-r}} \\ &= \frac{1}{\overline{c}}\left[(1-P) + P(1-\overline{c}) - \left[(1-P) + P(1-\overline{c})^{1-r}\right]^{\frac{1}{1-r}}\right]\end{aligned} \tag{10}$$

where $\overline{c} = \frac{c}{y}$. Normalization into dimensionless numbers ($\overline{v}$ and $\overline{c}$) allows the insurance value to be expressed as a fraction of intervention cost ($\overline{v}$) and intervention cost to be expressed as a fraction of income ($\overline{c}$). Given r, normalization allows $\overline{v}$ to depend only on two variables $\overline{c}$ and P. Note that increasing the value of P will (up to a point) increase $\overline{v}$.

The ECEA in this section proceeds in two parts. The first part (Section 3.1) presents results for a base case scenario using the methods and data described in Section 2. The second part (Section 3.2) builds on the base case scenario to extend to two additional considerations: (i) borrowing and asset selling by the poor as ways of inter-temporally smoothing consumption in the face of treatment cost risks; and (ii) inclusion of the prevention of secondary TB cases.

3.1. Base case scenario

The results for the base case scenario are listed in Table III, for public finance to increase coverage to 90% of a population of 1,000,000 in India. The total number of lives saved would be about 80 per year. Table III exhibits

[12]Some of these empirical estimates are for the inter-temporal elasticity of substitution that, although formally identical to the coefficient of relative risk aversion, characterizes a conceptually distinct utility function.

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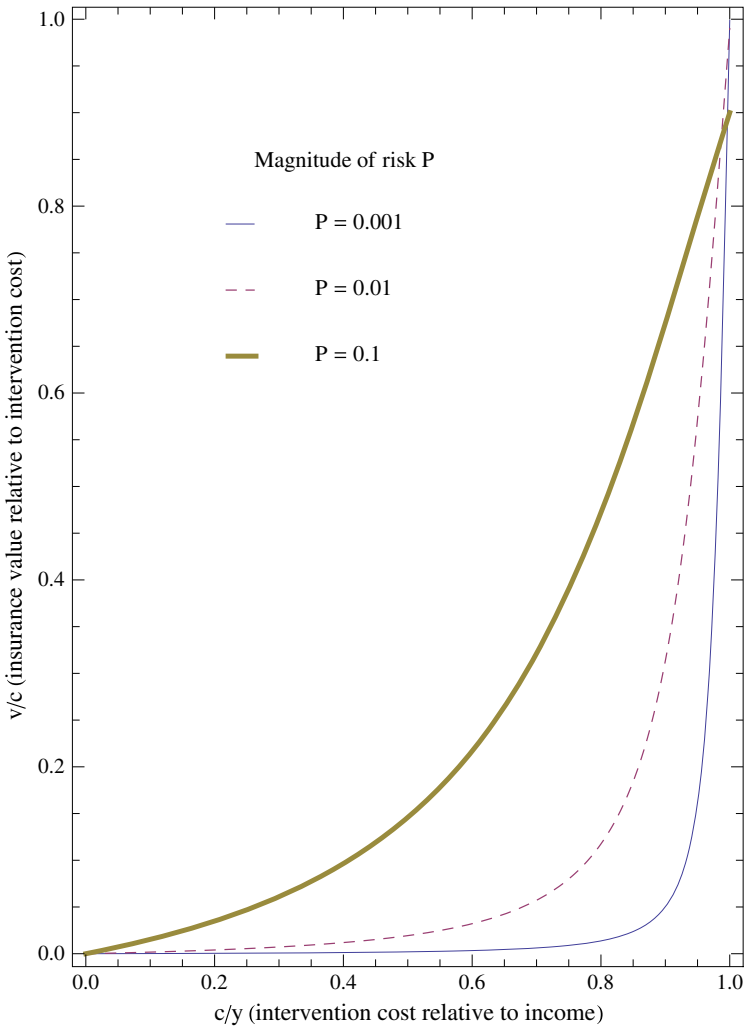

Figure 1. Individual money-metric value of insurance (relative to intervention cost) as a fraction of intervention cost (relative to income)

Table III. Base case results: public finance of tuberculosis treatment to 90% coverage (per million population)

Outcome	Total	Income quintile I	Income quintile II	Income quintile III	Income quintile IV	Income quintile V
Tuberculosis deaths averted	80	40	25	12	3	0
Private expenditures crowded out[a]	29	6	6	7	6	4
Insurance value[a]	9	5	2	1	1	0

[a]Figures are expressed in thousands of 2011 US$.

the distribution of the lives saved across different income quintiles; the health benefits would be concentrated among the bottom two income quintiles (80%) as TB is more incident among these income groups. The total of private expenditures averted by the program would be about $29,000. The bottom two income quintiles would benefit from about 40% of the private expenditures averted. The total (incremental) treatment costs incurred by UPF would be about $65,000. The total insurance value would be about $US9000, and 80% of it would accrue

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to the bottom two quintiles. Figure 2 shows how the insurance value would vary with income and illustrates that for higher income individuals, self-insurance entails limited welfare losses (as insurance value flattens and becomes small).

3.2. Alternative scenarios

3.2.1. 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 and Nundy, 2005); about 70% of TB patients borrowed money on account of illness in South India (Muniyandi *et al*., 2006). 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, a lower interest rate for borrowing by poor people.

To introduce access to capital markets into the analysis—in contrast to the base case with having no capital markets—we take as an illustrative example institutional arrangements that allow individuals to take a loan at an interest rate m, over a period of n years, as an alternative to UPF. For example, assume half of those individuals currently not obtaining treatment (in all income quintiles) would now take such a loan when they are confronted with TB treatment expenditures of c. The annual payment for the loan, l, would be

$$l = c\frac{m}{1-(1+m)^{-n}}, \tag{11}$$

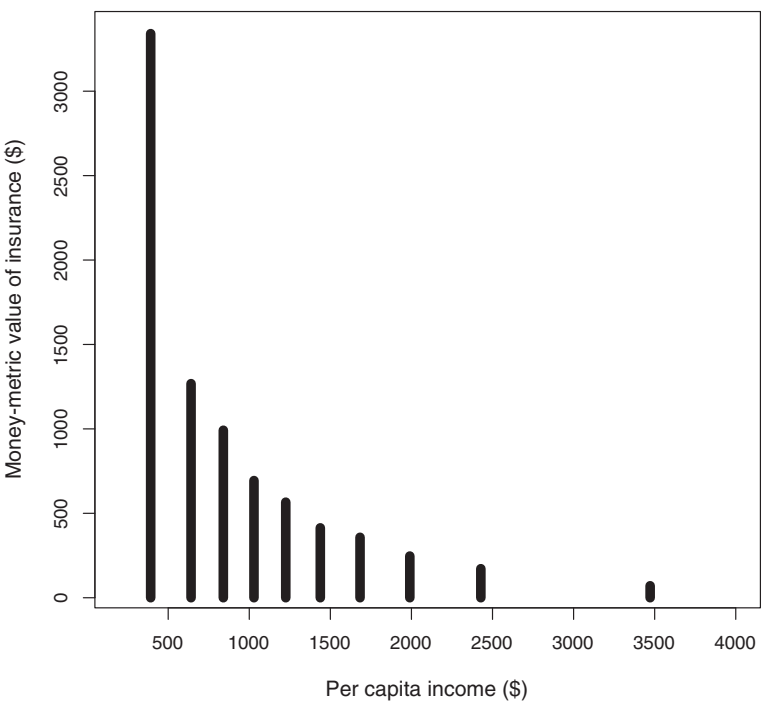

Figure 2. Money-metric value of insurance to the currently uninsured

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and the total debt for the borrower (present value) would become

$$D = \sum_{k=1}^{n} \frac{l}{(1+q)^k} \tag{12}$$

where q is the borrower's personal discount rate. The inclusion of improved capital markets in the model leads to a change in the private expenditures averted as individuals who borrow would now face private expenditures of D. We assume an annual interest rate $m = 0.20$, TB treatment costs of \$100 and \$50, for DOTS and non-DOTS treatments (purchased respectively in proportions as indicated in Table II), a loan period $n = 10$ years, and a personal discount rate $q = 0.03$.

In this example, improved capital markets would save about 30 lives due to the increased treatment uptake (Table IV). Private expenditures would now be created (−\$25,000) and shifted toward the bottom two income quintiles (80%). The present value of total debt associated with borrowing would be \$203 (\$102 for non-DOTS treatment). The values of annual payment, debt associated with borrowing, insurance value, and private expenditures averted would increase as the interest rate increases (or the adequacy of capital market improvements decreases) (Appendix C in supporting information). This example illustrates that access to capital markets for the poor can serve as a substitute for insurance (UPF) in averting TB deaths. Improving access to capital markets would have the advantage of lower costs to the public sector and improvements in the net income position of the top two income quintiles. It would have the disadvantage of burdening the poor with heavy debt.

3.2.2. Inclusion of the prevention of secondary tuberculosis cases. In this case, we assume that each TB case treated by UPF can subsequently avert one active TB case over the next few years (based on Murray *et al*., 1990). With the subsequent cases averted, whose extent is determined by the same assumptions used as in the base case scenario, corresponding private expenditures would also be averted. Consequently, the number of TB deaths averted and of private expenditures averted brought by UPF increase and the number of TB deaths averted and the insurance value would remain substantially concentrated among the bottom two quintiles, with 80% and 60%, respectively (Table V).

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 build on CEA in assessing consequences in three dimensions in addition to total costs and aggregate health outcomes: protection against financial risks, direct financial implications, and distributional consequences across income strata of a population. We illustrated ECEA by applying it to evaluation of UPF of TB treatment in India. Under plausible assumptions, our ECEA example concluded that replacement of private finance for TB treatment in India with UPF could lead to both substantial health gains and financial risk protection benefits, both concentrated among the poor. This ECEA illustrated the feasibility of quantifying the financial protection consequences of public finance of a specific intervention thereby facilitating informed consideration of financial protection outcomes in the design of an essential package of publicly financed health services.

Table IV. Variant 1 results: improved capital markets allow borrowing to finance tuberculosis treatment (per million population)

Outcome	Total	Income quintile I	Income quintile II	Income quintile III	Income quintile IV	Income quintile V
Tuberculosis deaths averted	29	13	10	5	1	0
Private expenditures crowded out[a]	−25	−12	−8	−4	−1	0
Insurance value[a]	0	0	0	0	0	0

[a]Figures are expressed in thousands of 2011 US$.

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Table V. Variant 2 results: effects of treatment on prevention included (per million population)

Outcome	Total	Income quintile I	Income quintile II	Income quintile III	Income quintile IV	Income quintile V
Tuberculosis deaths averted	119	61	37	17	4	0
Private expenditures crowded out[a]	34	9	8	7	6	4
Insurance value[a]	10	6	2	1	1	0

[a]Figures are expressed in thousands of 2011 US$.

Our base case analysis also illustrates how UPF can be used as a mechanism to bring in quality and technical efficiency by crowding out the purchase of lower quality treatments.[13] Expensive and ineffective medicines are often used in lieu of cheaper and more effective available interventions. For example, in many low-income and middle-income settings, ineffective drugs are overused at very high OOP costs. Crowding out unnecessary medicine expenditures can both save substantial funds and improve quality control (WHO, 2010). We also extended our base case scenario to assess the introduction of improved access to capital markets at (relatively) low interest rates. Our analysis suggests that improving the capacity of the poor to go into debt for high payoff medical care (such as TB treatment) can partially 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 and the economic consequences of debt, especially as they vary with income levels (Banerjee and Duflo, 2007; Kruk *et al*., 2009).

Our economic evaluation of UPF for TB treatment in India requires caveats. First, a detailed assessment would provide more realistic assumptions regarding disease modeling with the use of a dynamic framework (Castillo-Chavez and Song, 2004) and drug resistance benefits, for example. Second, more comprehensive estimates of costs for TB (e.g. households' transportation costs, earnings, and productivity impacts) should be included in the future. Our focus was on the cost of treatment, and we excluded the consequences of earnings/productivity reduced by the disease. For example, working days lost due to TB can range from 30 to 90 in South India (Muniyandi *et al*., 2006; Muniyandi *et al*., 2008). Subsequent indirect costs from loss of earnings can be substantial (Ananthakrishnan *et al*., 2012), which would—in the absence of other forms of social insurance—importantly increase the insurance benefits provided by UPF. Third, there is a lack of a detailed description and corresponding pricing of the existing underlying mix of public versus private providers of TB treatment. Indeed, Indians are overwhelmingly using the private sector (although with important regional variation), which accounts for 80% of outpatient visits and 60% of inpatient expenditures (Sengupta and Nundy, 2005). In addition, private TB treatment is often more expensive; private practitioners advise more tests and supplement additional medicines (Uplekar *et al*., 1996). Standard regimens recommended by WHO cost on average five times less than regimens prescribed by private doctors (Uplekar and Shepard, 1991). A refined assessment would thus also provide improved estimates of the price and income elasticity of demand for treatment of different types.

Our ECEA is sensitive to key assumptions. First, it is sensitive to the coefficient of relative risk aversion—about which there is no clear consensus in the literature. A sensitivity analysis (Appendix B in supporting information) found the distribution of estimated insurance benefits to remain similar, despite their magnitude being substantially altered. This does not prevent using ECEA for a comparative analysis across health policies and interventions as long as the coefficient selected (e.g. $r=3$) is maintained consistently across analyses. Second, insurance benefits are sensitive to the level of TB treatment cost as a share of income. When baseline TB treatment cost is increased by 50% (comparison between Table III and Table D.I, Appendix D in supporting information), total insurance benefits from UPF rise from $9000 to $23,000. Third, financial barriers are not the only barriers preventing individuals from seeking care: lack of information and distance are also important, for example. Primary health centers in India are not always easily accessible because of poor travel conditions

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

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(Muniyandi *et al*., 2006). Health services may not always be accessible or even available after the removal of financial barriers; coverage increase may thus not be feasible, and the extent of subsequent health gains from UPF (as stated in equation 2) may be significantly reduced in the absence of concomitant supply side intervention. Marginal costs of TB treatment provision may increase dramatically toward universal coverage. Appendix D (Table D. III in supporting information) explores how UPF benefits may vary with alternative assumptions for marginal costs of TB treatment.

This paper presents the ECEA results 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. With appropriate underlying assumptions, including distributional weights, one could aggregate the results and present cost-benefit analysis results.

Future work should examine alternative policies besides UPF and specifically who should financially contribute and in which way. Important considerations include the following: government revenues to create pooled funds, refunds to cover transport costs, microcredit schemes, etc.; and progressive contributions of the richest to avoid insufficient funding for the needs of the poorest (WHO, 2010). This analysis focused on specific consequences of UPF including distributional consequences and the money-metric value of insurance provided. Other potentially important aspects not incorporated here include the reduction of adverse selection (in environments where voluntary health insurance is otherwise an option), moral hazard and its efficiency costs, the social safety value of protection against lost labor, and the socio-economic impact on children and women.[14] Finally, the framework introduced can be applied to the economic evaluation of other 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, 2008). Perhaps, most importantly, it could be applied to evaluate a main policy alternative to UPF, which is pro-poor public finance—public finance only for the provision of care to the poor. A recent policy overview (Jamison *et al*., 2013) has pointed to the importance of achieving efficiency in financial risk protection. ECEAs provide an analytical tool for doing so as this paper illustrates with the example of UPF in India.

CONFLICT OF INTEREST

The authors have no conflict of interest.

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[14]For instance, 10% of children drop out of school in order to supplement parental income when parents contract TB in India (Geetharamani *et al*., 2001; Muniyandi *et al*., 2006). In addition, although UPF for TB treatment in India is probably pro-male, as TB is about twice as incident among men than among women in India (Rao, 2009; IHME, 2013), women probably receive more financial protection benefits on average per case because they are likely to be poorer.

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