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Methodology

Estimating and Comparing Health and Financial Risk Protection Outcomes in Economic Evaluations

Stéphane Verguet, MS, MPP, PhD, Ole F. Norheim, MD, PhD

ABSTRACT

Objectives: Improving health and financial risk protection (FRP, the prevention of medical impoverishment) and their distributions is a major objective of national health systems. Explicitly describing FRP and disaggregated (eg, across socioeconomic groups) impact of health interventions in economic evaluations can provide decision makers with a broader set of health and financial outcomes to compare and prioritize interventions against each other.

Methods: We propose methods to synthesize such a broader set of outcomes by estimating and comparing the distributions in both health and FRP benefits procured by health interventions. We build on benefit-cost analysis frameworks and utility-based models, and we illustrate our methods with the case study of universal public finance (financing by government regardless of whom an intervention is targeting) of disease treatment in a low- and middle-income country setting.

Results: Two key findings seem to emerge: FRP is critical when diseases are less lethal (eg, case fatality rates $<1\%$ or so), and quantitative valuation of inequality aversion across income groups matters greatly. We recommend the use of numerous sensitivity analyses and that all distributional health and financial outcomes be first presented in a disaggregated form (before potential subsequent aggregation).

Conclusions: Estimation approaches such as the one we propose provide explicit disaggregated considerations of equity, FRP, and poverty impact for the development of health sector policies, with high relevance for population-based preventive measures.

Keywords: economic evaluation, equity, financial risk protection, priority setting.

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Introduction

Economic evaluations of health interventions estimate the total health gains (HG) (eg, deaths or disability-adjusted life-years [DALYs] averted, quality-adjusted life-years [QALYs] gained) per given budget expenditure.[1,2] For each intervention evaluated, an incremental cost-effectiveness ratio is computed, which provides a single figure of merit that summarizes costs and health benefits of the intervention. Based on such league tables, analysts can rank the interventions to be prioritized for funding, yet many have argued that multiple other features of policy should be explicitly incorporated in economic evaluations. For instance, improving the distribution in population health and protecting from the financial risks of illness are major objectives of health systems,[3,4] integral to the World Health Organization discourse on universal coverage.[5,6] Health economic evaluations and outcome metrics such as DALYs[7] and QALYs[8] should ideally include the distributional impact of interventions within the whole population (eg, per socioeconomic group) and their financial risk protection (FRP) benefits (ie, impact on avoiding impoverishing illness-related out-of-pocket [OOP] expenditures). This would enable enhancing health system performance by identifying "best buys" in terms of equity and poverty reduction when investing in health interventions.

Therefore, extended cost-effectiveness analysis (CEA)[9,10] was developed to evaluate health interventions in 4 dimensions: first, the HG that can be expressed in terms of deaths or DALYs averted; second, the illness-related OOP costs (eg, disease treatment costs) averted and the associated FRP benefits for individuals that can be estimated in terms of catastrophic or impoverishing expenditures[11,12] averted; third, the distributional impact that is health and financial outcomes per socioeconomic group (eg, wealth quintile); and fourth, the costs of policy (eg, borne by government). This is an attempt to point to the interventions that provide broader (toward multiple outcomes) value for money and that should be prioritized in the design of essential benefits packages.[13-15] This approach explicitly assesses the distributions in both health and FRP gains per given budget expenditure on an intervention. While displaying various outcomes, it reports on the major objectives of improving levels and distributions of population health and FRP, to identify interventions efficiently maximizing health system performance. Along with other equity-

informative economic evaluation methods such as distributional CEA,[16-18] extended CEA has made important contributions to the priority setting literature.[19] In place of a single figure of merit aggregating across all the evaluated dimensions, such as the incremental cost-effectiveness ratio, it displays health and FRP benefits in a disaggregated manner across socioeconomic groups.

Multicriteria decision analysis (MCDA)[20,21-23] has long promoted using various dimensions into priority setting deliberations. Importantly, equity outcomes, say via explicit attention to the poor or to special subgroups, have been included into MCDA. MCDA defines indicators, including equity and FRP criteria, which analysts can process either in a disaggregated manner, say via structured deliberation,[21] or further aggregate, say via scores and additive or multiplicative weights,[22] toward yielding one summary figure.[20,21-23] The US second panel on cost-effectiveness in health and medicine also discussed ethical and distributive considerations and using appropriate sensitivity analyses.[24] In this regard, the distributional CEA approach pioneered by Cookson et al[17,18] provides an explicit aggregation of health outcomes along income groups (using inequality aversion parameters).

The International Society for Pharmacoeconomics and Outcomes Research value frameworks[25-27] and other authors[21-23,28,29] have discussed displaying a variety of disaggregated and context-specific elements as inputs into priority setting deliberations and values assessments of health technologies, toward developing more comprehensive economic evaluations and "augmented" CEA.[20,27] This can help document the uncertainties in estimating each outcome and weighting each against one another and, importantly, increase transparency (and uptake) of the methods used. In this article, we build on this scholarship and propose a synthesis of disaggregated health and FRP outcomes. This can be interpreted as performing a "reduced" MCDA that strictly reports on the preeminent health system mission of improving (efficiently) levels and distributions of health and FRP.[4] Thus, analysts can use such results from which they can compare interventions across multiple dimensions (eg, health vs FRP benefits) and inform structured deliberation based on either such disaggregated outcomes or their aggregation. We develop an algebraic money-metric formulation with distributional impact, FRP and HG, to enable explicit comparison. First, we expose our methods, illustrated then by the case study of universal public finance (UPF, financing by government regardless of whom an intervention is targeting) of disease treatment in a low- and middle-income country (LMIC) setting (Results section). Lastly, we discuss key findings: aversion to inequality across income groups matters greatly, and FRP gains become important (vis-à-vis HG) when case fatality rate (CFR) is $<1\%$ or so. These broad insights can assist decision makers in setting priorities. We also offer some directions for future work.

Methods

This section has 2 parts. First, we expose our approach to estimating health and financial outcomes across socioeconomic groups. Second, we present a range of input parameters to illustrate these approaches with the case study of UPF in a LMIC setting.

Modeling Approach

Computing disaggregated health and financial outcomes

In computing health benefits (eg, deaths averted) of intervention, we disaggregate gains across income quintiles. In quantifying FRP benefits of intervention, we build on formulations of the welfare gains associated with reductions in risk exposure to disease-related expenses.[9,30-33] All details are given in Appendix A, section 1, pp.1 to 5, in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.08.004.

We evaluate introducing UPF for treating a certain disease D in a given population. We derive mathematical formulations for a stylized impact assessment across income quintiles (y is individual income, and its distribution in the population is $f(y)$) on the following: the number of deaths averted by UPF, to which we assign a money-metric value, and the FRP benefits associated with eliminating private OOP expenditures (crowding out by UPF), to which we also assign a money-metric value.

Before UPF intervention, individuals (conditional on having D) obtain treatment for D at an OOP cost c with a utilization probability $u(y)$ (ie, depending on income [often, health services (disease treatment) utilization and intervention coverage increase with income]). In addition, D has an incidence that varies with income ($p(y)$ [often, disease burden (ie, incidence, prevalence, mortality) is more concentrated among the poor (decreases with income)]) and a CFR m (with untreated disease D). With UPF intervention, the number of deaths averted (per capita) would be:

$$HG \sim \int_0^{+\infty} sm(1-u(y))p(y)f(y)dy, \tag{1}$$

where s is treatment effectiveness against death (here, we assume that both publicly financed [via UPF] and privately financed treatments would yield similar treatment effectiveness. This assumption can be relaxed without affecting the qualitative nature of our results). The OOP expenditures averted would be:

$$\widehat{PE} \sim \int_0^{+\infty} cu(y)p(y)f(y)dy. \tag{2}$$

From the public financing perspective, the incremental costs incurred (comparing before/after UPF) would be:

$$\widehat{TC} \sim \int_0^{+\infty} cp(y)f(y)dy. \tag{3}$$

Drawing from the OOP expenditures averted and a utility-based model (with a constant relative risk aversion [CRRA] utility function of risk aversion r), the FRP gains would be:

$$\widehat{FP} \sim \int_0^{+\infty} I(P,y,c)f(y)dy, \tag{4}$$

where $I(P,y,c)$ (with $P = p(y)u(y)$) is the insurance value (see Eq. A.11 in Appendix A).

Estimating disaggregated health outcomes

We have constructed a money-metric value of FRP gains (Eq. (4)). Therefore, we convert HG (Eq. (1)) into the same numéraire: we transform the deaths averted using value of a statistical life (VSL) methods. All details are given in Appendix A, section 2, pp. 5 to 7, in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.08.004. The VSL in country C (V_C) can be related to the VSL in a reference country (V_{RF})[34]: $V_C = V_{RF}\left(\frac{Y_C}{Y_{RF}}\right)^{\varepsilon}$, where ε is income elasticity[34,35] and Y_C and Y_{RF} are gross national incomes per capita of C and of the reference country (a common reference is the United States: V_{US} = \$9 400 000[34]).

We can capture heterogeneity by income: high-income groups would typically have higher willingness to pay for mortality

Table 1. Initial case study: definition of input parameters and values assigned.

Parameter definition	Value	Source
Disease incidence ($p(y)$)	Average of p_0 = 100 per 100 000 population; 4 times greater incidence among poorest vs richest	Based on [9, 37, 40, 41]
Case fatality rate (m)	0.20	Based on [42]
Treatment cure rate (s)	0.82	Based on [37]
Treatment cost (c)	$150	Authors' assumptions based on [9, 37]
Treatment utilization/coverage ($u(y)$)	Before UPF: Average of 0.75 {0.55, 0.65, 0.75, 0.85, 0.95} across quintiles After UPF: 100% across all quintiles	Authors' assumptions, adapted from [9]
Income distribution ($f(y)$)	Simulated from: Gross national income per capita ($2000) and Gini (0.35) using truncated Gamma (2.3, 856) with lowest/highest income of $200/$20 000	Authors' assumptions, adapted from [9, 43, 44]
Coefficient of relative risk aversion (r)	1.1 (base-case)	Authors' assumption based on [34, 38]
Coefficient of inequality aversion (β)	1.3 (base-case)	Based on [39]
VSL income elasticity (ε)	1.2 (base-case)	Authors' assumption based on [34, 35]

Note. Input parameters used in the illustrative case study of UPF of TB treatment in a low- and middle-income country setting (approximate picture that is largely adapted from [9]). Target coverage of u = 100% across all quintiles with UPF is assumed for simplicity, and these inputs can be revisited in sensitivity analyses.
TB indicates tuberculosis; UPF, universal public finance; VSL, value of a statistical life.

reduction than low-income groups, yet such preferences are disregarded by using average VSL estimates (assigning V_C to every individual). Rather, to estimate VSL per income group, we repeat the procedure: $V_q(y_q) = V_{av}\left(\frac{y_q}{Y_{av}}\right)^{\varepsilon}$, where V_{av} is the average VSL (formerly V_C), y_q is income for a given group (eg, income quintile), and Y_{av} is average income (formerly Y_C).

Critically, willingness to pay for mortality reductions will be smaller for poorer individuals because of smaller disposable incomes (tighter budget constraints). Nevertheless, ethically, the society will not place a lower value on mortality reductions (or on the life) for a poorer individual in setting priorities. Hence, to monetize deaths averted across income groups, we must assign distributional weights based on social preferences that impose greater weight to lower incomes.[36] One possible strategy (among many) is to use income-varying weights (distributional weighting can be captured by $A'(y) \sim y^{-\beta}$, with β proxying inequality aversion. $A'(y)$ is derived from a standard utility function $A(y) = y^{1-\beta}/(1-\beta)$). We can then monetize Eq. (1):

$$\widehat{HG} \sim V_{av} Y_{av}{}^{-\varepsilon} sm \int_0^{+\infty} y^{\varepsilon-\beta}(1-u(y))p(y)f(y)dy. \quad (5)$$

Using Eqs. (3-4-5), we can compare health ($\widehat{HG}$) and FRP ($\widehat{FP}$) gains to incremental costs ($\widehat{TC}$) of UPF intervention.

Application to the Case Study of UPF

We illustrate our approach by analyzing UPF in a LMIC setting. We begin with a case study that initially draws from an economic evaluation of UPF of tuberculosis (TB) treatment (Table 1).[9] We then expand it to key scenario analyses (Table 2) and proceed to a comparative parametric examination of the values estimated for the health and FRP benefits.

We motivate the choice of UPF by the fact that OOP expenditures are often large without prepayment mechanisms. The incidence of catastrophic expenditures (OOP health expenditures surpassing a certain threshold of household consumption expenditures, an indicator used to measure FRP) can be as high as 15% in certain LMICs.[5,45,46] Furthermore, globally, TB caused an estimated 1.4 million deaths in 2019, and 8 LMICs accounted for more than two-thirds of this global burden.[37] Evidence also points that TB treatment is largely financed privately and imposes a substantial economic burden on the affected individuals.[47,48] Given such links between TB and impoverishment, one target of the World Health Organization's End TB Strategy is that no patients with TB face catastrophic

Table 2. The 4 key scenario analyses: brief summary of the situations explored.

Scenario	Description
Scenario 1	Baseline treatment utilization $u(y)$ is set at {0.95, 0.95, 0.95, 0.95, 0.95} across income quintiles, instead of {0.55, 0.65, 0.75, 0.85, 0.95}; ceteris paribus
Scenario 2	Treatment cost is reduced to c = $75, instead of c = $150; ceteris paribus
Scenario 3	Disease incidence $p(y)$ is raised to 1000 per 100 000 or 10 000 per 100 000 population, instead of 100 per 100 000; ceteris paribus
Scenario 4	Disease case fatality rate (m) is reduced to 0.02 (ie, 2.0%) and 0.002 (ie, 0.2%), instead of 0.20 (ie, 20%); ceteris paribus

Note. Alternative values assigned to input parameters used for each of the 4 key scenario analyses explored based off the initial case study of UPF of TB treatment.
TB indicates tuberculosis; UPF, universal public finance.

Table 3. Ratios of money-metric health gains across income levels.

Value of $\varepsilon-\beta$	−1.0	−0.5	−0.3	−0.1	0	0.1	0.3	0.5	1.0
Gains for y = \$500 divided by gains for y = \$2000 p and u constant	4.0	2.0	1.5	1.1	1	0.9	0.7	0.5	0.3
Gains for y = \$500 divided by gains for y = \$5000 p and u constant	10.0	3.2	2.0	1.3	1	0.8	0.5	0.3	0.1
Gains for y = \$500 divided by gains for y = \$2000 p and u vary	14.0	7.0	5.3	4.0	3.5	3.0	2.3	1.8	0.9
Gains for y = \$500 divided by gains for y = \$5000 p and u vary	663.1	209.7	132.3	83.5	66.3	52.7	33.2	21.0	6.6

Note. Ratios of money-metric values of health gains (at the individual level) across income levels of \$500, \$2000, and \$5000 (\$2000 corresponds to mean income, whereas \$500 and \$5000 correspond to incomes within quintiles I and V, respectively, of the gamma distribution of income set in Table 1). Distinct values of the difference $\varepsilon-\beta$ are explored, where ε is income elasticity and β is distributional weighting. Note: The case "p and u constant" corresponds to the average values listed in Table 1, whereas the case "p and u vary" corresponds to the income-varying values given.

expenditures.[37] Thus, understanding what could be the FRP benefits provided by UPF of TB treatment is highly relevant in LMIC settings.

All parameter values are gathered in Table 1. Importantly, we set base-case values for ε, β, and r at 1.2, 1.3, and 1.1, respectively. An abundant literature[9,30,31,50-53] has used r values of 3 (ie, high risk aversion), yet lower r values have also been used (eg, a 0.5 to 3 range).[49,54-59] Furthermore, Kaplow (2005)[38] suggests $r < \varepsilon$, and Robinson et al[34] (2019) recommend a base-case value of ε = 1 (along with numerous sensitivity analyses). Therefore, we selected r = 1.1, which lies on the lower ranges of risk aversion coefficients, and ε = 1.2 as being both close to 1 and $>r$. Finally, we set β = 1.3 as estimated by Layard et al[39] (2008) and as prescribed by the United Kingdom's treasury department.[60] All values of ε, β, and r were varied in sensitivity analyses.

Afterwards, in 4 scenario analyses, we varied key inputs (utilization, cost, incidence, CFR). First, we increased baseline utilization to 95% across all income quintiles: this emphasizes a situation where OOP financing is major and with no income gradient in healthcare utilization. Second, we lowered treatment cost to \$75: this highlights a situation with reduced OOP costs and decreased financial risk. Third, we raised baseline incidence to 1000/10 000 per 100 000: this mimics the alternative situation of more frequent diseases (eg, with high human immunodeficiency virus prevalence settings for TB[61]). Fourth, we lowered baseline CFR by 10/100 (2%/0.2%): this illustrates the alternative situation of less lethal diseases (eg, with other infectious diseases such as pneumonia and diarrhea[61]) or risk factors (eg, hypertension) (Table 2).

Finally, we expanded the initial case study and scenario analyses to anticipate the multiplicity of eventual epidemiological and financing situations. We compared (parametrically) variations in health and FRP gains (Eq. (4-5)) with respect to critical variables: incidence p, CFR m, cost c, income y, elasticity ε, and risk aversion r. In so doing, we point to the respective orders of magnitude in health and FRP gains to be expected in the context of specific disease categories (eg, high vs low incidence, high vs low CFR, costly vs affordable treatment).

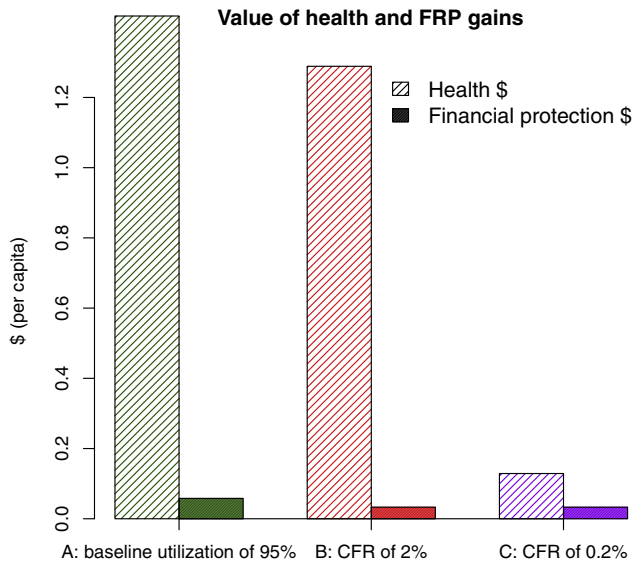
All calculations were conducted with Mathematica (12.1.1.0) and R Studio (1.2.5033).

Table 4. Initial UPF case study: per capita evaluations (\$) across income quintiles.

Outcome	I	II	III	IV	V
Health gains					
No distributional weighting (β = 0)					
ε = 1.2	5.497	7.335	6.492	4.278	1.262
ε = 1.0	13.515	15.951	13.084	8.052	2.175
ε = 1.5	1.436	2.290	2.271	1.658	0.660
ε = 2.0	0.156	0.330	0.395	0.342	0.145
With distributional weighting					
β = 1.3 and ε = 1.2	12.887	7.223	3.882	1.641	0.278
β = 0.5 and ε = 1.2	8.291	8.087	5.916	3.286	0.780
β = 0.7 and ε = 1.2	9.497	8.119	5.500	2.854	0.622
β = 1.0 and ε = 1.2	11.276	7.847	4.737	2.218	0.426
β = 1.5 and ε = 1.2	13.802	6.653	3.308	1.306	0.204
Financial risk protection gains					
r = 1.1	0.033	0.011	0.007	0.004	0.001
r = 1.5	0.049	0.015	0.009	0.005	0.002
r = 2.0	0.073	0.021	0.012	0.007	0.003
r = 3.0	0.138	0.033	0.019	0.011	0.004
Public sector costs	0.281	0.218	0.170	0.124	0.066

Note. Estimations of money-metric values of health and FRP gains (per capita), along with estimated public sector (government) costs across income quintiles for the illustrative case study of UPF of TB treatment; different values of income elasticity ε, distributional weighting β, and risk aversion r. I = poorest; V = richest.
FRP indicates financial risk protection; TB, tuberculosis; UPF, universal public finance.

Figure 1. Per capita values of health and FRP gains among the bottom income quintile for UPF. Key inputs are varied: (A) scenario analysis 1, where baseline treatment utilization is raised to 95% uniformly across all quintiles (green); (B) scenario analysis 4, where disease CFR is lowered to 2.0% (red); (C) scenario analysis 4, where disease CFR is lowered to 0.2% (purple).



Note: r = 1.1, β = 1.3 and ε = 1.2. CFR indicates case fatality rate; FRP, financial risk protection.

Results

We first examine the monotonic nature (with respect to income y) of the health and FRP gains (Eqs. (4-5)). This points to the potentially pro-poor nature of these formulations (before any numerical application). Second, we report on estimates of health and FRP gains for the initial case study of UPF and the key scenarios. Third, we interpret our findings when expanding to parametric analyses of comparing health and FRP gains.

Examining the Formulations of Disaggregated Outcomes

For HG ($\widehat{HG}$, Eq. (5)), the monotonic nature of the function $y^{\varepsilon-\beta}(1-u(y))p(y)$ will depend on the values of ε and β. Keeping $(1-u(y))p(y)$ constant: when $\beta > \varepsilon$, $\widehat{HG}$ will be greater for lower incomes; otherwise, it will be greater for higher incomes. Because often both $p'(y) < 0$ (larger burden among lower incomes) and $u'(y) > 0$ (greater utilization among higher incomes), the term $(1-u(y))p(y)$ will be larger for lower incomes. In this case, when $\beta > \varepsilon$, $\widehat{HG}$ will always be greater for lower incomes; when $\beta \leq \varepsilon$, $\widehat{HG}$ could become greater for higher incomes for certain (possibly rare) situations of income gradients in incidence and utilization. To illustrate this, ratios of individual-level values of $\widehat{HG}$ across selected income levels are presented in Table 3. We see that different ε and β lead to important differences across incomes. These differences are further mitigated by income gradients in incidence and utilization (see instances of varying p and u). In summary, the progressivity of $\widehat{HG}$ would be determined by the contrasting assumptions underlying ε and β, in addition to the kind of preexisting gradients in incidence and utilization. In other words, $\widehat{HG}$ will be pro-poor as long as $\varepsilon < \beta$.

For FRP, $\widehat{FP}$ (Eq. (4) and (A.12)) will most often be pro-poor, except in rare instances where both incidence and utilization are much greater among the rich (so that both compensate for the concavity of the CRRA function that largely exacerbates FRP valuation among the poor).

Application to the Distributional Impact of UPF

Initial case study of UPF of TB treatment

When studying UPF of TB treatment (Table 4), we observe that values assigned to deaths averted greatly vary with ε. Without weighting (β = 0), the valuation would be the highest in the second income quintile, followed by the first quintile only when ε = 1. With weighting ($\beta \geq 0.5$), HG would increase as income levels become smaller (ie, quintile decreases). As for FRP, we observe consistent pro-poor patterns for FRP gains whose values greatly vary with r. As expected for this highly lethal disease (CFR = 0.20), only when ε reaches higher values (1.5 and 2.0), FRP gains would be comparable with HG ($r \geq 2$).

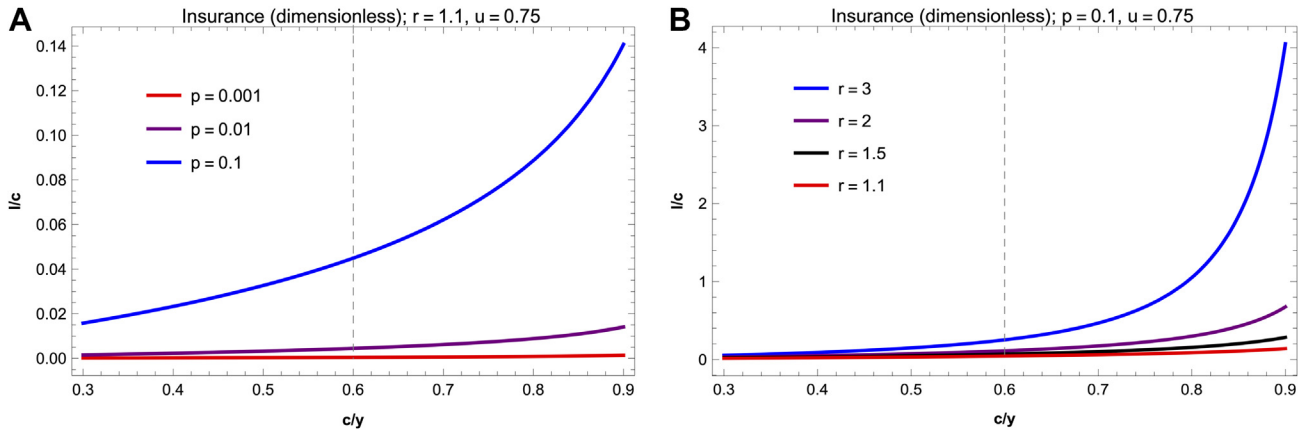
Expansion to 4 key scenario analyses

We now report on the impact of key inputs (Table 2). First (scenario 1), when increasing baseline utilization to 95% (uniformly), per capita FRP gains in the bottom quintile would increase to $0.058, whereas HG (in the same quintile) would decrease to $1.432 (Fig. 1A). This corresponds to a situation where there is almost a complete switch from private to public financing of healthcare with small improvements in utilization (hence small HG). Second (scenario 2), when treatment cost c is lowered to $75, evidently, we observe no change in HG but decreased FRP gains ($0.007 in the bottom quintile). Third (scenario 3), given that HG linearly increase with incidence (Eq. (5)), when incidence is multiplied by 10, $\widehat{HG}$ rises by 10 times (to $129), and similarly, when incidence is multiplied by 100 ($1290). As for FRP, when incidence $p_0 \leq 0.10$, the insurance value I scales linearly with p_0 (Appendix A.3.1, p.8 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.08.004): FRP gains would then also roughly increase by times 10 or 100 when incidence increases correspondingly. In summary, the relative magnitudes in health and FRP gains would be maintained regardless of changes in incidence. Fourth (scenario 4), when CFR is lowered by 10 or 100, evidently, FRP would remain unchanged, whereas HG would linearly decrease by a factor of 10 ($1.290 in the bottom quintile) or 100 ($0.129) (Fig. 1B,C). In this case, we see that FRP gains now become comparable with HG for lower CFR (ie, less lethal diseases with CFR of approximately ≤1%); examples of diseases with lower CFR include asthma (CFR of ~0.39%), chronic obstructive pulmonary disease (~1.88%), diabetes mellitus (~0.45%), diarrhea (~0.03%), epilepsy (~0.57%), and malaria (~0.30%) (rough CFR estimates calculated from either prevalence or incidence and deaths estimates as provided by the Global Burden of Disease study for lower- to middle-income countries for both sexes and the year 2019).[61]

Broader expansion to the parametric comparison of health and FRP gains

To examine variations in health and FRP gains with respect to key inputs, including incidence, CFR, utilization, and cost (and elasticity, risk aversion [distributional weighting is not considered in this section because our main purpose is to compare the orders of magnitude of health and FRP gains and not the distributional impact of UPF across income quintiles]), we derive dimensionless expressions (at the individual level) for HG ($\tilde{H} = \frac{H}{V_{av}} = \tilde{y}^{\varepsilon} sm(1-u)p$, with $\tilde{y} = \frac{y}{V_{av}}$; see Appendix A.3.2 p. 9 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.08.004) and FRP gains ($\tilde{I} = \frac{I}{c} = pu\left[\frac{-1}{\tilde{c}}\frac{1}{1-r}[(1-\tilde{c})^{1-r} - 1] - 1\right]$, with $\tilde{c} = \frac{c}{y}$; see A.3.1 p. 8 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.08.004).

Figure 2. Insurance value (dimensionless, $\tilde{I} = \frac{I}{c}$) of FRP gains at the individual level as a function of $\tilde{c} = \frac{c}{y}$. (A) Estimates for different incidence p: 0.001; 0.01; 0.1. Risk aversion r = 1.1 and treatment utilization u = 0.75. (B) Estimates for different values of risk aversion r (1.1; 1.5; 2; 3). Incidence p = 0.1 and utilization u = 0.75.



FRP indicates financial risk protection.

For FRP, as expected, gains augment with incidence (Fig. 2A) and r (Fig. 2B). Overall, FRP gains are highly sensitive to $\tilde{c}$: $\tilde{I}$ augments substantially as c nears y (when $\tilde{c} \to 1$; Fig. 2). This is because of the concavity of the CRRA function that exacerbates marginal utility for lower incomes and the impact of large OOP costs vis-à-vis low incomes, which explains the greater impact among lower incomes. For health, as expected, gains also increase with incidence (Fig. 3A) and decrease with larger ε (Fig. 3B). VSL estimates greatly vary with ε: V_{av} = \${324 698; 165 634; 60 347; 11 216} for ε = {1; 1.2; 1.5; 2}. In addition to ε, HG are sensitive to $\tilde{y}$: $\tilde{H}$ augments as y nears average income Y_{av} (in the absence of distributional weighting) (Fig. 3).

When comparing FRP and health (Figs. 2-3; using: p = 0.1, u = 0.75, m = 0.20, s = 0.82, r = 1.1, ε = 1.2, $\tilde{c} = 0.6$, $\tilde{y} = 0.2$), we obtain: $\tilde{I} = 0.045$ and I = \$7 (for c = \$150); $\tilde{H} = 0.0006$ and H = \$98 (V_{av} = \$165 634). In this case, we see that HG would be about one order of magnitude larger than FRP gains. Note that such relative magnitudes are almost entirely driven by the high CFR of m = 0.20 (for instance, with m = 0.02: H = \$9.8; with m = 0.002: H = \$0.98). The gap is also narrowed when $\tilde{c}$ becomes larger and for higher ε: H=\${22;2} for ε = {1.5;2}.

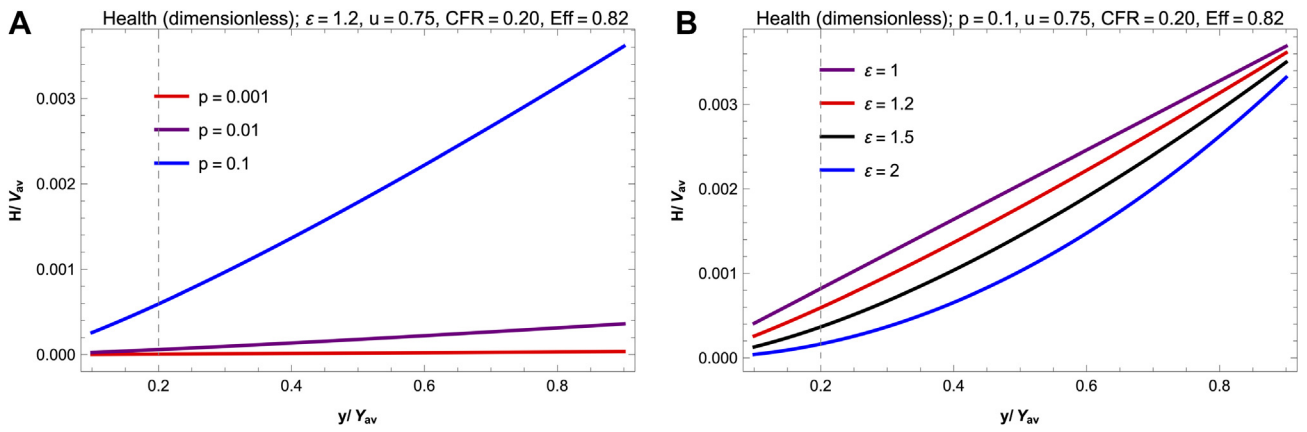
In fact, we can identify the orders of magnitude of CFR values for which FRP gains equal HG ($I = H$ or $\tilde{I} * c = V_{av} * \tilde{H}$ using the equations above for $\tilde{I}$ and $\tilde{H}$; see Appendix A.3.3 pp. 9-11 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2021.08.004), and then define a "CFR frontier." Above the frontier (higher CFR), $H > I$, whereas below (lower CFR), $H < I$. As an illustration, for high $\tilde{c}$ (say $\tilde{c} \geq 0.06$), $I > H$ for CFR below 2 to 10% (Fig. 4A), and the CFR parameter space for which FRP gains are greater (I>H) is shifted toward higher CFR (>2%-10%) as ε rises (Fig. 4B) and r rises (Fig. 4C).

Discussion

We exposed an approach to synthesize and compare health and FRP outcomes in economic evaluations. We proceeded in 2 steps: first, with an algebraic formulation that incorporates distributional health and FRP, and second, with estimating money-metric values of health and FRP gains.

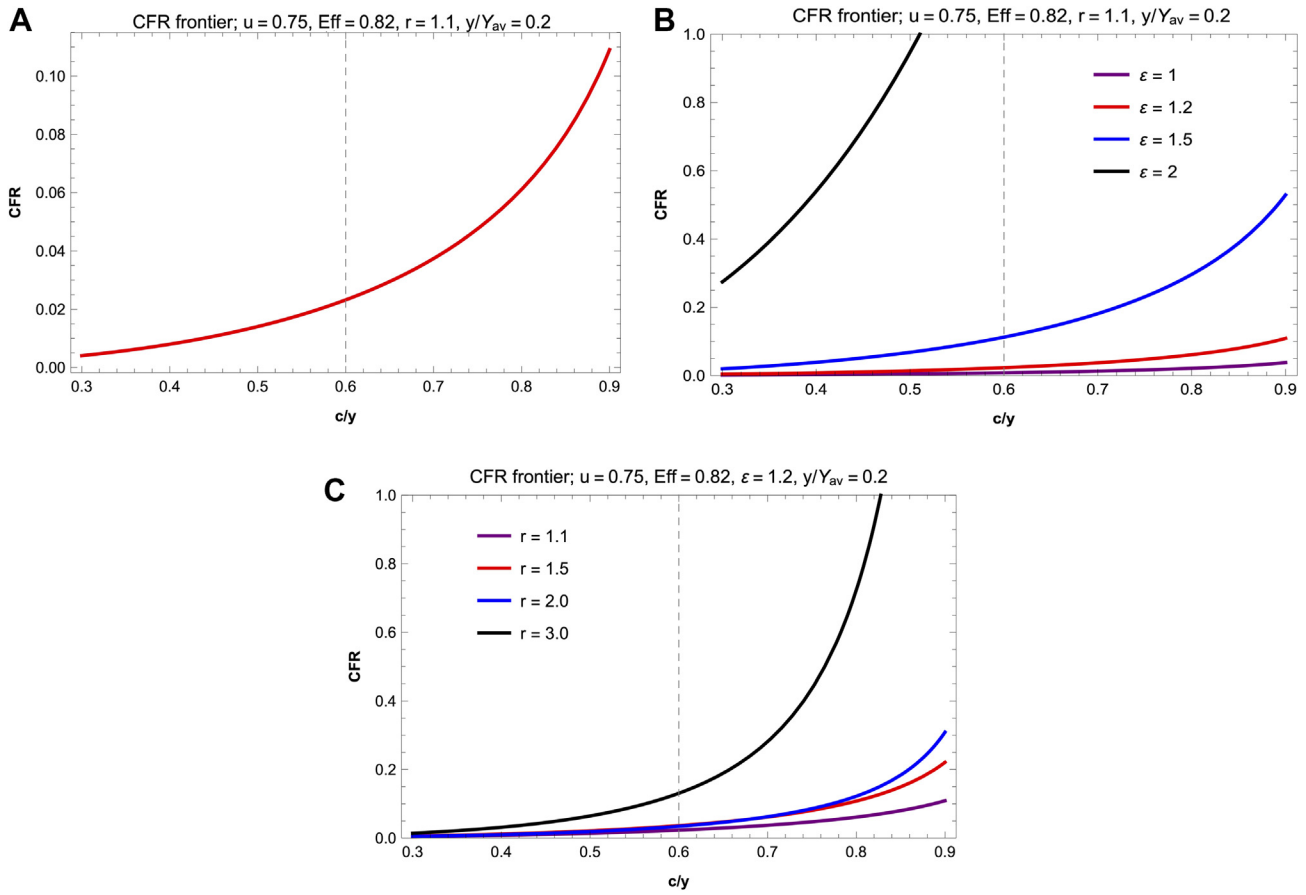
In applying our approach to the case study of UPF of disease treatment in a LMIC setting, we could first point to the pro-poor

Figure 3. Value (dimensionless, $\tilde{H} = \frac{H}{V_{av}}$) of health gains, at the individual level, as a function of $\tilde{y} = \frac{y}{Y_{av}}$. (A) Estimates for different incidence p: 0.001; 0.01; 0.1. Income elasticity ε =1.2, treatment utilization u = 0.75, CFR m = 0.20, and treatment Eff s = 0.82. (B) Estimates for different values of ε (1; 1.2; 1.5; 2). Incidence p = 0.1, utilization u = 0.75, CFR m = 0.20, and Eff s = 0.82.



CFR indicates case fatality rate; Eff, effectiveness.

Figure 4. CFR equality frontier, when FRP gains equal health gains ($I = H$) as a function of $\tilde{c} = \frac{c}{y}$. (A) Estimates for income elasticity $\varepsilon = 1.2$, treatment utilization $u = 0.75$, treatment Eff $s = 0.82$, risk aversion $r = 1.1$, and ratio $\tilde{y} = \frac{y}{Y_{av}} = 0.2$. (B) Estimates for different values of ε (1; 1.2; 1.5; and 2). Utilization $u = 0.75$, Eff $s = 0.82$, risk aversion $r = 1.1$, and ratio $\tilde{y} = \frac{y}{Y_{av}} = 0.2$. (C) Estimates for different values of r (1.1; 1.5; 2; and 3). Utilization $u = 0.75$, Eff $s = 0.82$, income elasticity $\varepsilon = 1.2$, and ratio $\tilde{y} = \frac{y}{Y_{av}} = 0.2$.



CFR indicates case fatality rate; Eff, effectiveness; FRP, financial risk protection.

features of FRP of UPF. In particular, FRP gains tend to accrue more to the poorest, and this is partly caused by the concavity of the CRRA utility function (making valuation of the ratio OOP costs to income very high when near 1). FRP gains substantially augment when OOP costs become large relative to income, which also points to the limits of such utility-based valuation of FRP for the poorest populations. Second, we could show how the ultimate distribution (across incomes) of HG would depend on both VSL assumptions (importantly elasticity ε) and distributional weighting (inequality aversion β). For example, when $\beta > \varepsilon$, HG will always be valued more among the poorest. This is also discussed by Samson et al[62] and Fleurbaey et al[63] in using distributional weights and evaluating morbidity risk reductions. More generally, we see that mortality reduction gains estimated via VSL methods would highly vary across income groups (especially so across extreme, say lowest vs highest, income groups) and that, because of disease burden being largely concentrated among the poor, slight adjustments to ε via β could redress a priori regressive estimations. Finally, in comparing health and FRP gains, we could see that, with UPF, FRP gains would no longer become negligible when values of CFR are <1% or so. This again points to the critical importance of FRP valuation for population-based preventive measures and for less fatal diseases, which also constitute the great majority of all diseases encountered.[61]

Nevertheless, our approach and applications to UPF are simple and, thus, present a number of major limitations. First, our framework only includes distributional impact in the domains of health and FRP. The motivation was that these are 2 major objectives of health systems,[4] yet other dimensions could be added to this selection of outcomes including spillovers to other sectors such as education and the local economy.[64] In particular, the financial implications to household caregivers' time and the crowding of both disease and financial burden could be large and greatly increase the estimated FRP if such secondary effects of UPF were included. Expanding OOP costs and FRP to incorporate broader societal impact (eg, productivity effects) could be an important next step. Illness shocks infer not only OOP costs (c) but also consumption expenditures (y) through wages: the productivity effects, say with sicker individuals more likely to face both increased OOP costs and reduced productivity (overall income), could be large. Financial risks and OOP expenditures could further be augmented to include nonmedical costs (eg, transport costs to seek treatment) and wages lost because of illness (including caregiver time): this will be important when dealing with chronic illnesses such as, for example, mental health conditions or dependence. Moreover, our case study only estimates lives saved, but could easily be extended to say QALYs gained. Second, our mathematical computation is subject to a number of choices

commonly implemented in priority setting exercises that rely on the social preferences of the decision maker. Foremost, the values used for the input parameters, importantly income elasticity, risk aversion, and distributional weighting can critically drive the quantitative findings. This leaves uncertainty, all the more because a variety of values and interrelations for ε, r, and β have been put forward in the literature.[9,34,38,39] A common recommendation, though, would be to perform sensitivity analyses if the range of reasonable values for each parameter is known.[36] For instance, based on our study, we would propose the following: ε ranging from 0.6 to 1.2 and ≥ 1 when going from high-income to low-income settings,[35] r from 0.5 to 3.0 based on the literature and our exploratory findings, and β from 1.1 to 1.4 (Layard et al[39] estimates a 1.16-1.37 95% confidence interval). In addition, our mathematical prescriptions, including monetization of HG and CRRA functions for FRP that rely on concave transformations, constitute only one approach. Nevertheless, such prescriptions could be consistent with several types of social welfare functions, including Atkinson's[65-67] and utilitarian functions.[68] Alternatively, one could use other formulations differing from such exponent-based functions, and FRP gains could be valued using other metrics such as catastrophic or impoverishing expenditures.[11] Third, although our disaggregated display of outcomes provides transparency in the quantitative findings (Table 4), it does not necessarily provide definite insight into what is good value for money and how selection of interventions across income groups should systematically operate. Nevertheless, it suggests that aversion to inequality matters substantially when estimating distributional impact and that FRP gains are most important to consider (in addition to HG) when CFR is $<1\%$ or so. These broad insights can certainly assist decision makers to make "all-things-considered" judgments. Finally, evidently, our numerical applications to the case study of UPF of TB treatment themselves are simplified: this is where our subsequent parametric examinations could provide further insights.

Conclusions

Our approach is a steppingstone toward explicitly incorporating equity and FRP into priority setting. Needless to say, we recommend that all information be first presented in a disaggregated form (before potential subsequent aggregation). Although the analytical agenda ahead remains vast, including, for example, valuing willingness to pay for FRP as a stand-alone dimension or in combination with HG across income groups, estimation approaches such as the one we propose here provide explicit disaggregated considerations of equity and poverty impact in the development of health sector policies.

Supplemental Material

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Author Affiliations: Department of Global Health and Population, Harvard T.H. Chan School of Public Health, Boston, MA, USA (Verguet, Norheim); Department of Global Public Health and Primary Care, University of Bergen, Bergen, Norway (Norheim).

Correspondence: Stéphane Verguet, MS, MPP, PhD, Department of Global Health and Population, Harvard T.H. Chan School of Public Health, 677 Huntington Ave, Boston MA 02115, USA. Email: verguet@hsph.harvard.edu

Author Contributions: *Concept and design:* Verguet, Norheim
Acquisition of data: Verguet
Analysis and interpretation of data: Verguet, Norheim
Drafting of the manuscript: Verguet, Norheim
Critical revision of the paper for important intellectual content: Verguet, Norheim
Statistical and mathematical analysis: Verguet
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Supervision: Verguet

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