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Distributional impact of infectious disease interventions in the Ethiopian Essential Health Service Package: a modelling study

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ABSTRACT

Objectives Reducing inequalities in health and financial risk are key goals on the path toward universal health coverage, particularly in low-income and middle-income countries. The design of the health benefit package creates an opportunity to select interventions through established criteria. The aim of this study is to examine the health equity and financial protection impact of selected interventions, along with their costs, at the national level in Ethiopia.

Design Distributional cost-effectiveness analysis.

Population The eligible population for all selected interventions is assumed to be 10 million.

Data sources Data on disease prevalence and population size were gathered from the Global Burden of Disease database, and average health benefits and program costs are sourced from the Ethiopian Essential Health Service Package (EHSP) database, national surveys and other publicly available sources.

Intervention A total of 30 interventions were selected from the latest EHSP revision and analysed over a 1-year period.

Outcome measures Health benefits, social welfare indices and financial protection metrics across income quintiles were reported.

Results We found 23 interventions that improve population health and reduce health inequality and four interventions reduce both population health and health inequality. Additionally, three interventions improve population health while increasing health inequality. Overall, the EHSP interventions provide a 0.021 improvement in health-adjusted life expectancy (HALE) per person, with a positive distributional equity impact: 0.029 (26.9%) HALE gained in the poorest and 0.015 (14.0%) in the richest quintile. Similarly, a total of 1 79 475 cases of catastrophic health expenditure were averted, including 82 100 (46.0%) cases in the poorest and 17 900 (10.0%) in the richest quintile.

Conclusion Increasing access to the EHSP improves health equity and financial protection. Improved access to selected EHSP interventions also has the potential to provide greater benefits to the poorest and thereby improve social welfare.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ A quantitative approach is used to analyse the population's net health benefits, distributional consequences and financial protection impacts of health interventions.
- ⇒ A summary measure is employed to explicitly evaluate the trade-offs between maximising total health and eliminating unfair health inequalities.
- ⇒ We focused on infectious disease interventions; the finding may not be representative of other disease interventions not included here.
- ⇒ The distribution of health opportunity costs and level of health inequality aversion were estimated using proxy parameters and non-local published data, respectively. The results might be improved using more precise and country estimates.

INTRODUCTION

Equity in health status, access to quality healthcare services and prevention of financial risks are all central concerns in health systems and policies.[1] Ensuring a fairer distribution of good health through reducing health inequalities is fundamental in moving toward universal health coverage (UHC).[2] Inequities in health are caused by multiple factors but largely arise from unequal distribution of the social determinants of health and uneven provision of public health interventions to populations in need.[3 4] The importance of eliminating avoidable disparities or inequities in health has long been emphasised by scholars and international agencies.[1–6]

Many low/middle-income countries (LMICs) aim to achieve UHC by the provision of quality health services without financial risks.[7] However, a larger proportion of individuals lack access to essential service coverage and have to pay for their own medical care, which puts them at risk for financial hardship.[8] Financial risks in healthcare refer to the potential economic burden that households may face when seeking healthcare services. The indicators that help to quantify the extent of this, includes catastrophic health expenditure (CHE), which measure the percentage of household health spending exceeding a specified income threshold (eg, 10%, 25%, etc), while impoverishing health expenditure measures the proportion of households pushed below the poverty line due to healthcare costs.[9 10]

Infectious disease and poverty may lead to a vicious cycle, where poverty increases the susceptibility to infectious diseases, and the burden of these diseases further deepens poverty due to high healthcare costs and productivity loss. Both low-income and middle-income households are affected by this. Low-income families, who are already vulnerable to economic burden, may be further pushed into poverty because of the high costs, while middle-income households may experience financial stress as they struggle to afford healthcare services. Implementing efficient financial protection, such as health insurance and social protection programmes, ensures that both middle-class and low-income households can access healthcare without crippling financial risks, which are essential to break this cycle.[11]

The progress towards UHC objective requires efficient and equitable use of scarce resources and available funds.[5 12] Priority-setting is necessary so that highly cost-effective interventions in line with national health system objectives may be implemented. Consequently, not all health services will be available to everyone, so a set of cost-effective essential health service packages should be provided to those in greatest need first, which includes, pregnant women, elderly population, rural residents, the poor, marginalised communities, etc.[5]

Selecting interventions to be included in a publicly financed essential health benefit package (HBP) requires balancing cost-effectiveness, financial risk protection (FRP) and reducing disparities (eg, across socioeconomic status, geographic locations or population subgroups).[5 13] In Ethiopia, a low-income country with Africa's second largest population, the first Ethiopian Essential Health Service Package (EHSP) was defined in 2005 and revised it in 2019 for the period 2020–2025.[14 15] The government then committed to providing a list of health promotion, disease prevention, curative and rehabilitative services with various payment mechanisms, such as, free of charge, cost sharing and cost recovery. The package lists around 1000 interventions to be delivered through the various health system delivery platforms, either at the primary, secondary or tertiary level.[14 15] Its content was informed by a consultative process of experts who discussed the interventions to be included based on several criteria, including disease burden, cost-effectiveness, budget impact, equity, FRP, public acceptability and political acceptability.[14] However, equity and FRP were considered either informally or qualitatively in the EHSP revision due to the lack of quantitative evidence on the equity impacts of interventions.

The EHSP now needs to be implemented while sequentially prioritising certain interventions and delivery platforms. This is critical, as current service coverage gaps, health inequalities and financial risks are substantial in Ethiopia. For instance, health outcomes vary significantly by region, residence, gender, age and socioeconomic status.[16] In addition, the financial risks associated with seeking care are substantial; about 31% of the country's total health expenditure was financed by out-of-pocket (OOP), resulting in around 2% of Ethiopian households facing CHE in 2017.[17 18] Therefore, policies and EHSPs aimed at reducing health inequality and ensuring FRP should be geared toward universal measures across the country and scaled proportionally to address disparities among disadvantaged populations.[3 5] In most cases, the impact of a decision on overall population health is consistent with reducing health inequalities and financial risks, but there may be trade-offs between these objectives, such as when providing health services to disadvantaged groups necessitates additional resources; also, providing primary prevention for relatively healthy people yields greater health gains than providing care for the severely ill.[19 20]

Importantly, health equity and FRP are key objectives of the Ethiopian health system in addressing the persistent burden of communicable diseases, non-communicable diseases and other public health problems.[15] Interventions directed towards preventing and controlling communicable diseases have the potential to improve equity and narrow the health gap between rich and poor population subgroups.[21] We focus on infectious diseases because they are a major public health concern and affect individuals, communities and the entire population in LMICs. A substantial portion of morbidity and mortality is attributed to these diseases.[22] Furthermore, the prevention and control of infectious diseases contributes to the achievement of the global commitment made to the sustainable development goals. Therefore, drawing from the recommendations of Ethiopia's EHSP, in this paper we quantitively appraise the equity and FRP impact of selected infectious disease interventions, along with their costs, at the national level. Specifically, we estimate the impact across socioeconomic groups (ie, income quintiles) on reducing health inequalities and financial risks by selecting 30 communicable disease interventions so that the interventions with the greatest impact can be prioritised first under the limited budget available.

METHODS

Overview

We model the equity impact of a package of essential interventions for the prevention and control of infectious diseases in Ethiopia. The distribution of both the health and FRP benefits of each intervention across income quintiles was estimated. To do so, we first modelled the baseline distribution (pre-intervention) of health outcomes (quantified in health-adjusted life years) and FRP outcomes (quantified in cases of CHE averted) across income quintiles). Second, we examined how these two distributions change with the scale-up of each intervention (postintervention) by considering the distribution of health opportunity costs, that is, the forgone health benefits elsewhere in the health system resulting from the funding allocated to the infectious disease intervention.[20 23] The resulting values of pre-decision and post-decision benefit distributions were summarised and ranked in terms of health benefit, equity (ie, social welfare indices), and FRP.

Interventions and data sources

We focused our analysis on malaria, tuberculosis (TB) and HIV/AIDS along with other selected acute infections (eg, diarrhoea, pneumonia), as these are major causes of mortality and morbidity worldwide, including in Ethiopia.[24] We then selected interventions addressing the prevention and control of these infectious diseases that were included in the revision of Ethiopia's EHSP[14] (a complete list of the inputs and interventions selected is given in online supplemental tables S1 and S2). Estimates of population size (by age group), prevalence of disability (which is based on prevalence of years lost due to disability per 100 population) and mortality rate were sourced from the Global Burden of Disease (GBD) 2019 study.[22] For simplicity and due to the lack of empirical data, the population was evenly distributed across income quintiles. In addition, estimates from Ethiopia's National Health Accounts VI report were used to distribute the GBD's aggregate disability prevalence[25] whereas modelled mortality distributions from previous studies and the 2019 mini-Ethiopian Demographic and Health Survey (mini-EDHS) were used to distribute the mortality rate by age group across income quintiles.[26 27]

As for specific diseases, the prevalence of disease and the coverage of the corresponding interventions across income quintiles were primarily derived from national surveys, programme-specific surveys and reports, and the national District Health Information Software 2. For TB and HIV interventions, disaggregated inputs by income groups were not available in the sources and were distributed across income quintiles using proxy parameters from published sources. The efficacies of the interventions considered were gathered from the published literature while health services usage inputs were extracted from several sources, including household surveys and the published literature (see online supplemental appendix 1 for detailed inputs and data sources).

Data on the additional health benefits and costs of each intervention were extracted from the inputs of the most recent EHSP (2019) revision (online supplemental table S3)[28] and converted to a per-person basis for ease of analysis. The marginal productivity cost of healthcare or the cost-effectiveness threshold (ie, cost per disability-adjusted life years (DALYs) averted) for Ethiopia was derived using country-specific estimates of health opportunity costs (HOCs) in LMICs.[29] Furthermore, estimates for OOP payments associated with treatment of the diseases considered here were assembled from previous data collection exercises.[30–32] Costs were reported in 2019 US dollars using Ethiopia's consumer price index and an exchange rate of US$1=29.2 birr in 2019.[33]

Modelling approach

Step 1: estimation of the baseline health distribution

Here, we detail the several steps involved in our analysis. Equity in health can be measured using different indices depending on the implications for decision-making. Here, we used the idea of lifetime health to address concerns for health equity (ie, the number of healthy years potentially gained from birth to death). Therefore, the baseline distribution of lifetime health was calculated by combining population statistics on age-specific mortality rates, prevalence of good health (in the absence of disability) and population size. The baseline distribution for the Ethiopian population was estimated using HALE at birth. HALE is a summary measure of population health that captures the average number of years that a person of a given age can expect to live in full health (ie, expressed in healthy life years (HALYs) at population level).[34]

The first step in determining the baseline distribution of HALE is to calculate life expectancy for each income quintile. A standard technique based on abridged life tables for Ethiopia was used to estimate life expectancy for each income quintile by adjusting age-specific death rates from GBD according to the mortality distribution among under-five children (from the 2019 mini-EDHS) and adults (using results from a previously published modelling analysis).[26 27] Sullivan's approach[35] was then applied to the country life tables to produce age-specific estimates of years lived without disability as a fraction of total years lived in order to calculate HALE at birth for each income quintile.[36] We extracted the aggregate years lived with disability (YLD) rate by age groups from GBD. To distribute the total YLD burden across income quintiles, we used 10 linked disease specific YLD rates and their respective prevalence distributions to create overall morbidity weights.[25] The baseline distribution of lifetime health was constructed separately for each income quintile.

Step 2: estimation of the distributional impact of interventions

This step focuses on simulating the changes to baseline health distribution that could be attributed to the implementation of the interventions. A total of 30 interventions were selected from the latest EHSP revision[28] to evaluate the net health impact of one or more interventions on the baseline distribution of health. The reported average cost and health benefits (HALYs) from this revision were used to represent the cost and gross benefit of each intervention , respectively. The estimated total health benefit was based on a combination of average effect, quintile-specific disease prevalence (ie, number of cases) and coverage, with the latter two combined (with average cost being the basis for estimating the total costs). Instead of considering the targeted beneficiaries of an intervention, the full general population was chosen as the relevant group for equity analysis. In this analysis, an incremental annual coverage of 95% (as used in the

EHSP database) was retained for each intervention across income quintiles.

Furthermore, the additional cost of an intervention diverts or displaces resources from an alternative investment within the fixed budget of the health system. To account for this in the base case, the HOCs of an intervention were computed using a marginal productivity cost of healthcare of US\$176 per DALY averted.[29] The HOCs of an intervention were calculated by dividing the total cost of an intervention by the threshold cost per HALY value (ie, US\$176). This value was in the range of the cost-effectiveness estimates for Ethiopia (US\$10–US\$255).[37] The HOCs that could have resulted from implementing the next-best alternative intervention are assumed to have a similar distribution with the general pattern of healthcare usage.[25] Finally, the net health benefit (NHB) for each income quintile was calculated by subtracting the HOC from the incremental gross health benefit. The population NHB was translated to a per-person rate based on the population size of each income quintile and compared with the baseline health distribution to determine the lifetime health benefit of an intervention.

$$\mathrm{NHB}_{ij} = p_{ij} \times \mathrm{inc}_{\mathrm{cov}} \times \left(h_{ij} - \left[\frac{1}{k} \times c_{ij} \times \mathrm{prop}_j\right]\right) \quad (1)$$

Where,

NHB_{ij}	NHB of intervention i among income quintile j.
h_{ij}	average effect of intervention i among income quintile j.
p_{ij}	patient population of disease i among income quintile j.
k	cost-effectiveness threshold.
$\mathrm{inc}_{\mathrm{cov}}$	incremental coverage.
c_{ij}	average cost of intervention i among income quintile j.
prop_j	proportion of HOCs among income quintile j.

Step 3: estimation of health equity

The net health equity impact is estimated using inequality and social welfare indices. The inequalities in health by income quintile are estimated as the absolute difference between pre-intervention and post-intervention using the slope index of inequality (SII).[23] The SII assesses the absolute inequality in health status between the poor and richest population groups. It is generated using the regression of HALE on fraction rank across income quintile. Higher levels of inequality are indicated by larger SII values; a value of 0 denotes no inequality. The SII is converted into a relative scale by dividing it by the mean HALE, generating the relative index of inequality. The Atkinson index (with a level of aversion to inequality index of ε=10) was also used to characterise the size of disparity by aggregating the rate of population health gains across income quintiles into a single indicator.[38] The Atkinson index assesses the entire distribution and takes into consideration different levels of relative inequality aversion. It is a relative measure of inequality that explicitly incorporates normative judgments about social welfare (ie, the societal preference for reducing inequality). The inequality aversion parameter (ε) was taken from published sources and indicates the amount of population health that a decision-maker is ready to forgo to achieve a more equal distribution.[39] The Atkinson index[40] of inequality is estimated using the formula:

$$A_{\varepsilon} = 1 - \left[\frac{1}{n}\sum_{i=1}^{n}\left[\frac{h_i}{\bar{h}}\right]^{1-\varepsilon}\right] 1/\left(1-\varepsilon\right) \qquad (2)$$

Where n is the total population, h_i represents the HALY of the ith individual, $\bar{h}$ represents mean HALE and ε is the inequality aversion parameter. A social welfare index, equally distributed equivalent (EDE) level of health, is estimated by combining the mean level of health with Atkinson inequality indices. The EDE is defined as the mean level of health that ‘if it were equally distributed would generate the same level of social welfare as is obtained from the actual (unequal) distribution’.[40] In other words, it is the level of health in a hypothetical equal distribution of health that would make society indifferent between that equal distribution of health and the actual unequal distribution of health. The EDE level of health is estimated as

$$\mathrm{EDE}_{\varepsilon} = \left(1 - A_{\varepsilon}\right)\bar{h} \qquad (3)$$

The difference between mean health and EDE level of health for a given degree of inequality aversion reveals the average amount of health that each person in the population is willing to sacrifice to attain a perfectly equal distribution of health. Hence, the difference represents the cost of health inequality. In addition, the impact of the selected interventions was shown on an equity impact plane, with the population net benefit (measured in HALYs) on the y-axis and the equity benefit (measured in changes in EDE and NHB) on the x-axis.

Step 4: estimation of FRP impacts

The FRP benefits provided through public financing of selected interventions were measured using the number of cases of CHE averted. The rate of CHE averted depends on the prevalence of disease, intervention coverage, efficacy (for preventive intervention) and probability of seeking care. FRP benefits would result from curative intervention when switching from OOP payment to free of charge and would imply a reduction in cases of CHE proportional to the intervention coverage whereas, for preventive intervention, the reduction of disease would prevent OOP costs and associated CHE cases. To estimate the CHE metric, the distribution of income across quintiles is approximated using a gamma distribution derived from a gross domestic product per capita of US\$856 and a Gini index of 0.332 (Ethiopia).[41–43] A case of CHE was estimated for both the baseline and the intervention scenario when OOP spending exceeded the 10% threshold of household income. The baseline CHE, denoted by CHE_0, occurred when the following conditions were satisfied:

$$c_{\mathrm{in\ or\ out},j} > \mathrm{th} \times y_j \qquad (4)$$

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Where,

y_j household income in jth quintile.

$c_{\text{in or out},j}$ inpatient or outpatient out-of-pocket costs in jth quintile.

th threshold.

$$\text{CHE}_{av,j} = \text{Cov}_j \times \text{Eff} \times \text{CHE}_0 \text{ and } \text{Cov}_j \times \text{CHE}_0 \text{ (for curative interventions)} \quad (5)$$

Furthermore, the total cost was distributed according to the incremental coverage of each intervention across income quintiles.

Step 5: combination and ranking of metrics

The comparison and ranking of interventions were made according to the NHBs, EDE impacts and FRP benefits.

Sensitivity analysis

The effect of key parameters (such as disease prevalence, HOCs and the strength of aversion to health inequality) on our model outcome was investigated using one-way sensitivity analysis, specifically: (i) assigning equal distributions of prevalence rates; (ii) unequal distribution of disease prevalence (increased prevalence by 20% for the poorer and poorest quintiles but decreased prevalence by 20% for the richer and richest quintiles); (iii) varying the HOCs between one HALY gained per additional \$167 (lower) to \$221 (higher) expenditure[29]; (iv) assuming the opportunity cost weights are lowest in the poorest and richest quintiles (0.155, 0.23, 0.23, 0.23 and 0.155), is proportionately borne by lower quintiles (0.27, 0.22, 0.18, 0.18 and 0.15), and equally distributed across income quintiles (0.2, 0.2, 0.2, 0.2 and 0.2); and (v) varying the inequality aversion parameter from 8 (less concern for aversion to inequality) to 12 (more concern for aversion to inequality). The data analysis was conducted using R software (V.4.1.3).

Patient and public involvement statement

Patients or the public were not involved in the design, conduct, or reporting, or dissemination plans of this research.

RESULTS

Baseline demographics

The average baseline HALE in Ethiopia is 60.715 years whereas the average EDE HALE (Atkinson inequality aversion: ε=10) is 60.657 years, implying that the cost of inequality at baseline is 0.06 HALY gained per person (figure 1). The HALE at birth ranges from 59.6 years in the poorest quintile to 62.1 years in the richest.

Health inequality impacts

The selected EHSP interventions increase the baseline HALE and EDE of HALE by 0.0213 and 0.0219 years per person, respectively. At the population level, the selected EHSP interventions increase the NHB and EDE HALYs (ε=10) by 2 287 236 and 2 353 297, respectively, resulting in a 66 061 reduction in health inequality (around 2.9% of the NHB) (table 1).

Pneumonia, oral rehydration solutions (ORS) for diarrhoea treatment and uncomplicated malaria treatment in adults with microscopy were ranked as

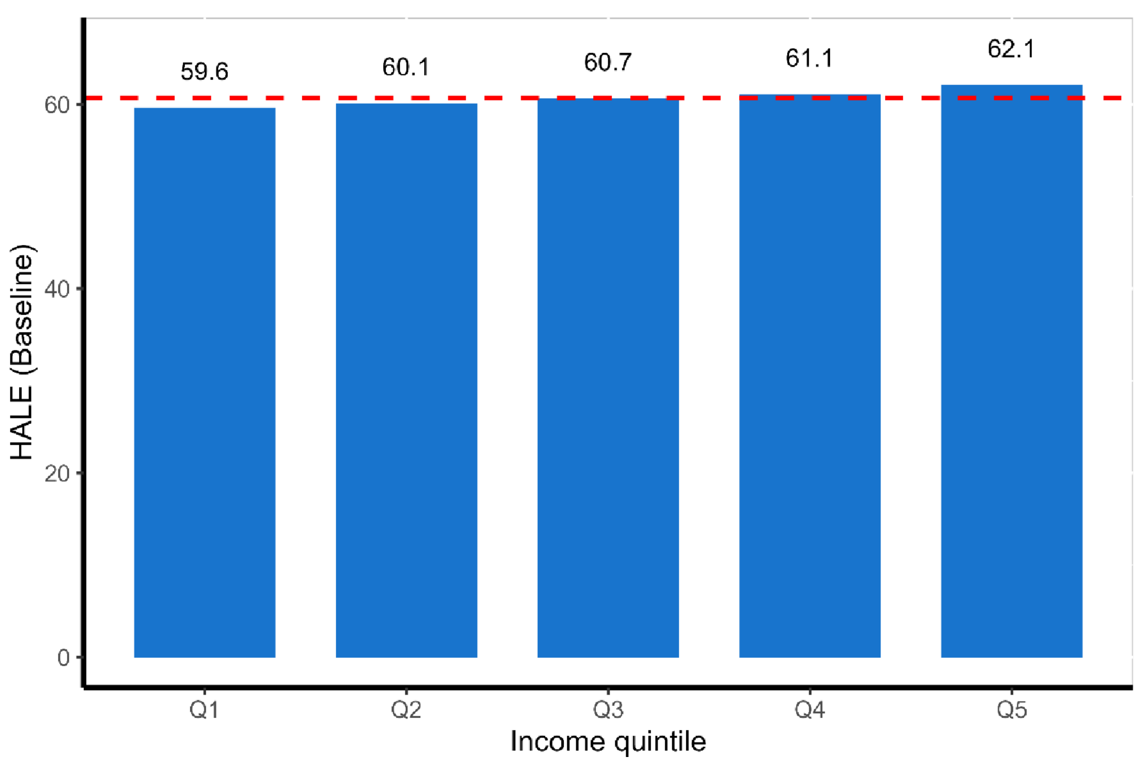

Figure 1 Baseline distribution of lifetime health in HALE in 2019 by income quintile in Ethiopia (Q1–Q5: poorest to richest; horizontal dotted line: average baseline HALE). HALE, health-adjusted life expectancy.

Table 1 Health benefits, inequality social welfare (EDE) and FRP impact of each intervention

Interventions	Population NHB	Rank NHB	Inequality ΔSII (×10^4)	Social welfare ($\Delta EDE_{A,\varepsilon}$)	ΔEDE-NHB	Rank ΔEDE	FRP (CHE)	Rank ΔCHE
Cotrimoxazole for children	−6928	27	0.78	−6621	308	27	0	
DS-TB treatment	867	18	0.39	1028	162	20	8719	7
DS-TB treatment and ART for TB	746	20	0.40	911	166	21	8129	8
DS-TB treatment and preventive therapy	562	24	0.41	732	169	24	31 062	2
DS-TB treatment and preventive therapy for children	680	22	0.40	846	166	23	38 298	1
DS-TB treatment, ART for TB, and preventive therapy	260	26	0.43	438	178	26	30 856	3
First-line ART men	54 767	9	−16.8	47 212	−7555	9	7325	9
First-line ART women	163 577	6	−37.96	146 912	−16 665	8	14 485	5
iPT for pregnant women	−14 888	29	1.3	−14 361	527	29	23	23
IRS	38 411	11	5.16	40 528	2117	11	294	20
LLIN	27 287	12	5.86	29 694	2407	12	890	18
Malaria treatment for pregnant women	−11 181	28	0.94	−10 798	383	28	44	22
MDR-TB treatment	897	17	0.72	1190	294	17	967	17
MDR-TB treatment and ART for TB	739	21	0.73	1039	300	19	1068	15
MDR-TB treatment and preventive therapy	570	23	0.74	873	303	22	1829	10
MDR-TB treatment and preventive therapy for children	750	19	0.73	1048	298	18	1426	12
MDR-TB treatment, ART for TB, and preventive therapy	275	25	0.76	588	313	25	1274	14
ORS for diarrhoea treatment	480 093	2	−1.03	480 931	838	2	1530	11
Paediatric ART	154 366	7	1.24	154 591	225	7	10 005	6
PMTCT	23 801	13	−7.18	20 629	−3172	13	259	21
Pneumonia treatment (children)	613 044	1	15.94	622 341	9297	1	17 137	4
Severe malaria treatment in children (microscopy)	3018	14	0.38	3174	156	15	771	19
Severe malaria treatment in children (RDT)	2155	15	0.72	2450	295	14	771	19
Syphilis detection and treatment (pregnant women)	40 255	10	1.84	41 142	888	10	0	
Treatment for dysentery (antibiotics)	1901	16	2.66	3095	1193	16	969	16
Uncomplicated malaria treatment in adults (microscopy)	256 310	3	32.89	269 755	13 445	3	0	
Uncomplicated malaria treatment in adults (RDT)	185 113	5	62.03	210 390	25 277	4	0	
Uncomplicated malaria treatment in children (microscopy)	193 356	4	24.81	203 501	10 144	5	0	
Uncomplicated malaria treatment in children (RDT)	139 646	8	46.79	158 721	19 075	6	0	
Zinc (diarrhoea treatment)	−63 212	30	10.53	−58 682	4530	30	1344	13
Total	2 287 236			2 353 297	66 061		179 475	

EDE is the level of health that if it were equally distributed would generate the same welfare as is obtained from the actual (unequal) distribution.
FRP is linked to the total patient costs averted by the interventions.
NHB is the difference between the direct health benefits and the health opportunity cost.
ART, antiretroviral therapy; CHE, catastrophic health expenditure; DS-TB, drug susceptible tuberculosis; EDE, equally distributed equivalent; FRP, financial risk protection; iPT, intermittent preventive treatment; IRS, indoor residual spraying; LLIN, long-lasting insecticide-treated net; MDR-TB, multidrug-resistant tuberculosis; NHB, net health benefit; PMTCT, prevention of mother-to-child transmission; RDT, rapid diagnostic test; SII, slope index of inequality; TB, tuberculosis.

the top three interventions with the greatest health benefit and equity impact based on social welfare analyses (table 1). In terms of financial protection, however, TB control interventions would come out on top. For instance, the potential inequality reduction of treating pneumonia was 9297 (ε=10) additional

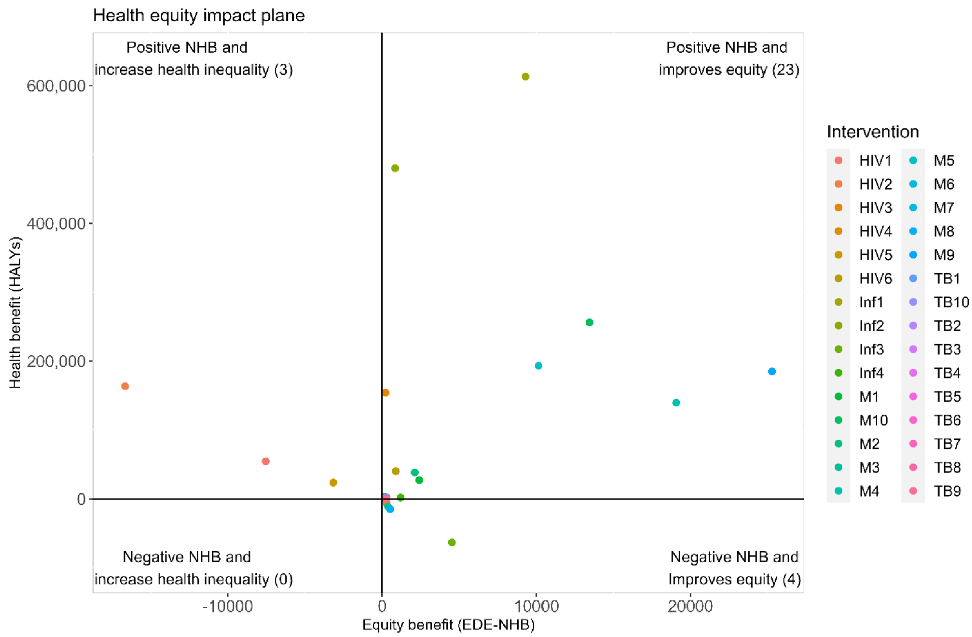

Figure 2 Health equity impact plane. HIV1: first-line antiretroviral therapy (ART) men; HIV2: first-line ART women; HIV3: paediatric ART; HIV4: cotrimoxazole for children; HIV5: prevention of mother-to-child transmission; HIV6: syphilis detection and treatment (pregnant women); Inf1: pneumonia treatment (children); Inf2: ORS for diarrhoea treatment; Inf3: zinc (diarrhoea treatment); Inf4: treatment for dysentery (antibiotics); M1: long-lasting insecticide-treated net; M2: indoor residual spraying; M3: malaria treatment for pregnant women; M4: uncomplicated malaria treatment in children (rapid diagnostic test (RDT)); M5: uncomplicated malaria treatment in children (microscopy); M6: severe malaria treatment in children (RDT); M7: severe malaria treatment in children (microscopy); M8: intermittent preventive treatment for pregnant women; M8: uncomplicated malaria treatment in adults (RDT); TB1: drug susceptible tuberculosis (DS-TB) treatment; TB2: DS-TB treatment and ART for TB; TB3: DS-TB treatment, ART for TB, and preventive therapy; TB4: DS-TB treatment and preventive therapy; TB5: DS-TB treatment and preventive therapy for children; TB6: multidrug-resistant tuberculosis (MDR-TB) treatment; TB7: MDR-TB treatment and ART for TB; TB8: MDR-TB treatment, ART for TB, and preventive therapy; TB9: MDR-TB treatment and preventive therapy; TB10: MDR-TB treatment and preventive therapy for children. EDE, equally distributed equivalent; HALY, healthy life year; NHB, net health benefit.

HALYs on top of the NHB of 613 044 HALYs. Similarly, the treatment of pneumonia averts 17 137 cases of CHE.

The prioritisation of interventions for inclusion in the EHSP based on positive NHBs would result in a composition of 26 interventions (out of 30), and the same composition would result if positive changes in EDE were used as a criterion for inclusion.

In addition, adding interventions to the package that have a positive health and equity impact requires an annual investment of more than $185 million.

The health equity impact plane shows that 23 EHSP interventions out of the total of 30 increase population health and reduce health inequalities, and they all fall in the northeast quadrant of the equity effect plane (figure 2). Three interventions, on the other hand, are in the northwest quadrant of the plane and increase population health while increasing health inequalities. For these three, there is a trade-off between the objectives of improving health and reducing health inequalities. In addition, four interventions reduce both population health and health inequalities, which fall in the southeast quadrant.

Health and financial protection inequality impacts across socioeconomic status

At baseline, the absolute difference in lifetime baseline HALE between the poorest and richest quintile (ordered ranking) was around 2.47, but, after the interventions, it was reduced to 2.45. Similarly, the richest quintile would have 4.14% more lifetime HALE than the poorest quintile at baseline, but this would drop to 4.11% when the interventions were implemented (table 2). The net inequality impact indicators are lower postinterventions, indicating that health inequalities have been reduced.

The selected EHSP interventions increase HALE, on average, by 0.021, with 0.029 (26.9%) in the poorest quintile and 0.015 (14%) in the richest quintile (figure 3; the postinterventions benefit is scaled to 100). Hence, the population in the poorest quintile can expect to live 62.47 years in good health compared with 63.57 for the population in the richest quintile. The EHSP interventions resulted in population NHBs of 616 748 and 315 923 HALYs in the poorest and richest quintiles, respectively.

The poorest quintile receives the greatest NHB and has the lowest opportunity cost. The HOCs increase as we move from the poorest to the richest. Similarly, a total of 179 475 cases of CHE were averted, with 82 100 (46%)

Table 2 Summary of health benefits and inequality in the health distribution

No.	Parameters	Baseline	Interventions	Net inequality impact
Inequality in the distribution of health				
Absolute measures				
1	Absolute gap (HALE)	2.4663	2.4523	0.014
2	SII (HALE~fractional rank)	2.9524	2.9367	0.016
Relative measures				
3	Relative gap (HALE)	0.04135	0.04109	0.00026
4	RII	0.04863	0.04835	0.00028
Summary based on combination of level and distribution of health				
5	EDE Kolm, α=0.2 (absolute)	60.645	60.667	0.022
6	EDE Atkinson, ε=10 (relative)	60.657	60.679	0.022

EDE, equally distributed equivalent; HALE, health-adjusted life expectancy; RII, relative index of inequality; SII, slope index of inequality.

cases in the poorest and 17 900 (10%) cases in the richest quintile (figure 3). TB-related treatment and preventive treatments were the key interventions linked to a larger reduction in CHE cases (ie, more than two-thirds of the benefit).

Sensitivity analysis

If the disease burden is uniformly distributed across income quintiles, the potential value of a reduction in health inequality is reduced by half while financial protection increases just a little. In contrast, assuming an unequal disease burden that disproportionately affects the poorer and poorest, the potential value of lowering inequality is doubled (ie, 0.135 million HALYs gained), with a modest increase in financial protection. Similarly, if the HOC is evenly distributed or falls disproportionately on the poorer and lowest quintiles, the projected value

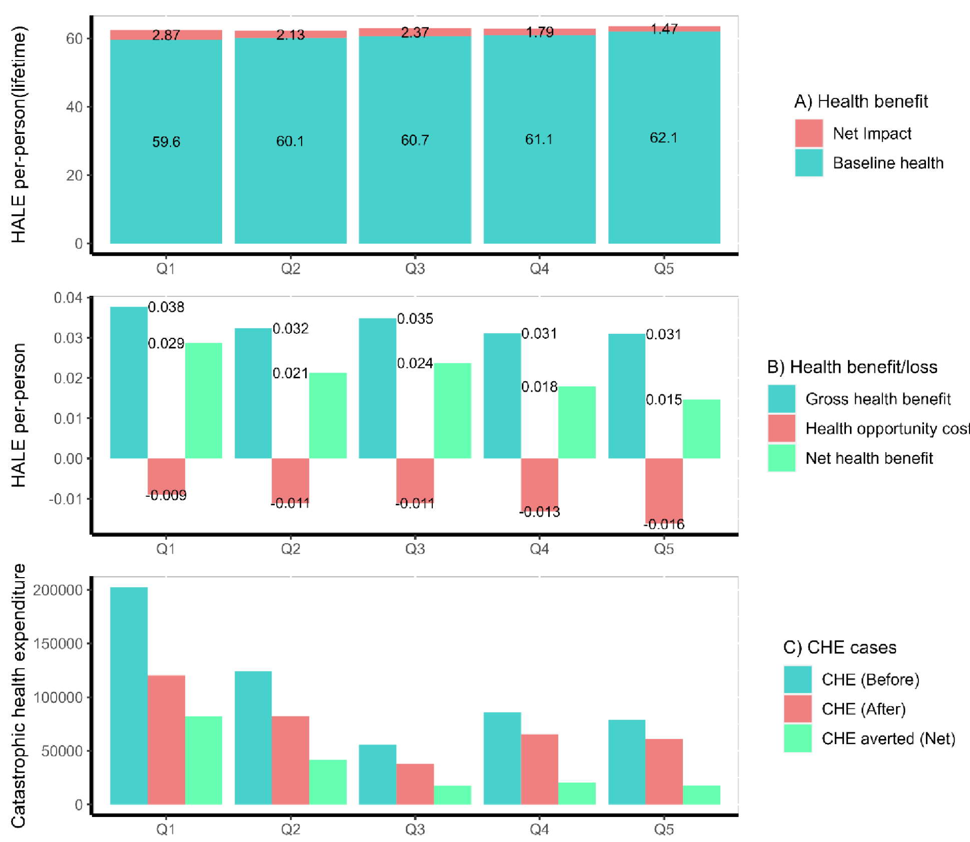

Figure 3 (A) Impact of selected interventions in the distribution of lifetime health (benefits are scaled at 100); (B) comparison of gross, net health benefits and opportunity costs; (C) distribution of financial protection across income quintiles in Ethiopia (2019). HALE, health-adjusted life expectancy.

of the reduction in health inequality is reduced by half compared with the baseline whereas, if the lower quintiles bear a proportionate share of the opportunity cost, the selected intervention will raise the cost of inequality to 3400 HALYs gained. Assuming a low or high level of aversion to health inequality has a huge impact on EDE health (online supplemental table S4).

DISCUSSION

We employed quantitative methods to estimate the impact of infectious disease interventions on health benefits, equity impact and financial protection. This study shows the importance of augmenting traditional cost-effectiveness analysis (ie, maximising health benefits) with equity and financial protection impact analysis to optimise the selection of services in countries' HBP designs.

In this study, improving the coverage of 30 interventions resulted in substantial net health gains, equity impacts and financial protection even though the impact and programmatic costs vary across each intervention. Prioritising interventions based on population health gains and reducing inequality (as measured by EDE of health: ε=10) would provide a similar set of services (ie, include 26 interventions out of 30 in the HBP).[44] In LMICs like Ethiopia, where OOP payments for services take a large portion of the available funds, creating financial burden for households. The FRP metrics would also be an important criterion for prioritising healthcare interventions or services. According to this study, the impact of each intervention on financial protection differs from the impact on health, and the rankings are not interrelated. As a result, policy-makers' weights and preferences for health, equity and financial protection criteria must determine the optimal composition of the package.[45] Because none of the currently published studies incorporate user-defined weighting of health, equity, and financial protection, more research is needed in this area.

Furthermore, more than 85% of the interventions have a positive NHB, whereas the remaining 15% have a negative impact, suggesting that the forgone care due to selection of the latter interventions may result in greater health and non-health benefits. Specifically, pneumonia, diarrhoea and malaria treatments provide the greatest health benefits when compared with other interventions. The impact of interventions on NHBs and equity depends on assumptions about healthcare coverage, distribution of disease prevalence, HOCs, per-patient NHBs and eligible population size. In addition, public financing of interventions would be critical for financial risks, and, in our study, diseases with higher OOP costs (eg, TB) resulted in bigger financial protection benefits, which is similar to a prior study's findings.[46]

Similarly, most interventions included in this study target the most common diseases in the poorest quintile, and we found that the poorest population subgroups benefit the most from current health service usage patterns.[44] This benefit represents the distribution of incremental benefits attributed to the adoption of each intervention; nevertheless, a uniform percentage point increase across income quintiles would still benefit those groups with the highest baseline health status and ensure that they receive a disproportionate share of total health benefit relative to the rest.[47] Enhancing intervention coverage among the poorest groups may be necessary to close the baseline coverage gap between poor and rich households.[48]

Limitations

Even though the analytic technique used here presents a mechanism for considering the three outcome indicators (health benefit, equity and financial protection) during priority-setting, there are some important limitations to acknowledge. First, we focused on infectious disease interventions using publicly available data from the most recent EHSP; the results may not be representative of other disease interventions not included here, so the socioeconomic distributions of morbidity, healthcare coverage and direct benefits may differ. Second, the distribution of HOCs across population groups was assumed to resemble general healthcare consumption patterns and was used as a proxy for health expenditure marginal productivity. Third, we did not incorporate any potential non-health-related factors influencing the net health and non-health benefits across income quintiles even though we included several input parameters, including epidemiological, programmatic, clinical efficacy, patient costs, etc. In addition, the financial risks related to using health services can also have negative impact on mental health, including an increase in anxiety, depression and psychological discomfort, which is not covered in this study. The development of comprehensive and patient-centred approaches to infectious disease control and management also needs to consider both the economic and mental health dimensions of these diseases.

Overall, this study simulated the distribution of health gains, inequality reductions, and financial protection impacts of health interventions using the EHSP in the context of limited distributional data. The finding may assist policymakers in identifying which policy is more effective in promoting overall health, equity and financial protection as well as offering insight into the EHSP's overall impact on reaching full coverage.

CONCLUSION

Improving access to infectious disease interventions has the potential to improve overall health, equity and financial protection. The potential impact of the selected interventions varies in terms of population health, health equity and financial protection; therefore, trade-offs between these outcomes must be carefully evaluated when prioritising interventions in the benefit package. Even if access to specific EHSP interventions also had the potential to give greater benefits to the poorest, its impact on improving HALE, reducing health inequalities, and financial protection are limited by baseline low usage rate among this group.

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